THE ILLUMINATING ENGINEER

LIGHT
LAMPS
FITTINGS
AND
ILLUMINATION

THE JOURNAL OF GOOD LIGHTING

Official Organ of the Illuminating Engineering Society

FOUNDED IN LONDON 1908

Edited by
J. STEWART DOW

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ACETYLENE
PETROL-AIR
GAS
ETC.

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Special Features:

Some Further Properties of Glass and their Application in Illuminating Engineering—The International Illumination Congress in the United States—Colour-Lighting—Electric Light in the Garage—Gas at Three Large Exhibitions—Lighting at the North-East Coast Exhibition—News from Abroad, etc.

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Some Further Properties of Glass and their Application to Illuminating Engineering

THE paper read last year by Dr. S. English on the properties of glass and their application to illuminating engineering* was generally considered to be one of the most interesting that had been read before the Illuminating Engineering Society. That paper dealt mainly with such problems as transparency, colour and other properties affecting the transmission, reflection and diffusion of light. The supplementary paper read before the Society on April 30th was devoted mainly to such qualities as durability and heat-resisting power. Like the preceding one it was illustrated by numerous well-staged experiments and was equally instructive.

These qualities, whilst perhaps not quite so obviously vital to illuminating engineering, are actually of very great importance. Anyone who has had experience in fitting up numbers of glass bowls or reflectors in a large installation will agree as to the importance of minimum breakage. Unexpected failures in illuminating glassware are apt to give rise to more bitter complaints from consumers than defective illuminating qualities. In the case of street lanterns, especially those used with high-pressure gas, durability and heat-resisting power are of considerable moment. Other special instances were mentioned in the discussion by Lt.-Commander Haydn T. Harrison, who referred to the very exacting requirements of glassware used in the Navy, and by Dr. Walsh, who quoted some experience with ships' navigation lanterns.

The occasional breaking of glass is looked upon by many people as a natural and inherent defect. Certainly, as Dr. English remarked, ordinary glass is somewhat brittle and is incapable of bending except when very thin. A fair proportion of breakages, therefore, may be set down to rough usage and carelessness on the part of the user. Yet the mechanical strength of glass may be much greater than is commonly realized. Many breakages are due to faulty manufacture and particularly to imperfect annealing. It was interesting to hear from Dr. English, who illustrated the setting-up of strain within glass by several attractive experiments, that accidental fractures due to this cause are much less than in pre-war days, and that the time of annealing ordinary-sized glassware has, during this period of 15 years, been reduced to one to one and a half hours, whereas as much as eight hours was formerly necessary.

Thermal endurance is a more complex quantity. Failures in this respect gave much concern during the war, and we recall that the problem of devising a suitable test was studied by a committee working under the Department of Scientific and Industrial Research. The method of determining the thermal endurance of illuminating fittings recently proposed by the committee working under the British Engineering Standards Association† was the result of much patient work. It would seem, judging from the discussion between the author and Dr. Hampton, that this question still presents difficulties as regards definition. Dr. English, for his tests on reflectors, employed a somewhat more precise form of test, and the latest types of reflectors seem to have given excellent results. The same applies to the remarkable improvement in durability ascertained by ingenious special tests, which Dr. English was able to report and on which he was justly complimented. The study of the composition of glass for illuminating purposes is a matter for the expert. But one gathers from the paper that one important principle, both as regards thermal resisting power and durability, is to avoid the use of soda or at least diminish its use to a minimum, notwithstanding the fact that this constituent facilitates easy melting and working. It may also be noted—and this is a point which illuminating engineers should bear in mind—that the design of illuminating glassware has a material influence on durability. We can recall lighting units that seemed to be devised in such a manner as positively to encourage the accumulation of dirt and corrosive material, but fortunately most makers of lanterns and glassware for outside use now recognize the importance of furnishing shapes that can be readily kept clean.

At the commencement of his paper Dr. English professed himself "an incurable optimist." Although material advances have been made during recent years he sees no reason to doubt further advances. Alterations in the composition of glass, as ordinarily understood, have chiefly been concerned with relatively small proportions of the constituents. Indeed, as Dr. English has shown, an apparently small change may have outstanding results. But it is always conceivable that a transparent medium, suitable for the use of illuminating engineers, of

* *The Illuminating Engineer*, May, 1928, p. 133.

† British Engineering Standards Specification No. 324, 1928.

radically different constitution may be devised. A transparent material, otherwise resembling glass but very much lighter, would, for instance, have a direct influence on the design of bowls and glassware of large dimensions. Various forms of fused quartz have already proved of great value from the standpoint of thermal endurance, and the tendency to cloudiness in such materials, which helps to diffuse the light, is not invariably a drawback. One would also like to have heard more of the recently introduced flexible "glass," which seems destined to have many useful applications. Little has yet been published regarding its possibilities from the illuminating engineering standpoint.

The International Illumination Congress

THE admirable summary of the proceedings at the International Illumination Congress, held in the United States last year, which was presented by Mr. G. H. Wilson at the meeting of the Illuminating Engineering Society on May 14th, must be deferred until our next issue. We think everyone present at this meeting will agree that Mr. Wilson discharged his difficult task in a very able manner. Readers will recall the very comprehensive list of papers included in this journal last year.* It was felt that some record of the chief conclusions reached at Toronto and Saranac should appear in the *Transactions* of our Society, and Mr. Wilson was kind enough to step into the breach and prepare a most useful record.

The paper was also of interest in view of the prospective congress to be held in this country in 1931, for which preparations have already commenced. The National Illumination Committee and the Illuminating Engineering Society will be jointly responsible for this important event, and we are confident that every member of the Society will wish to do all that he can do personally to render it an outstanding success.

Most of those who joined in the discussion of Mr. Wilson's paper alluded to the 1931 Congress and the aims to be kept in view were very ably summarized by the President (Mr. C. C. Paterson). In most fields of engineering work, as he pointed out, the world is suffering from past history—from the individualism almost inevitable when workers in different countries are feeling their way in a new subject. In those days there were few facilities for international action. Fortunately illuminating engineering, which is little more than 20 years old, has developed during a period when the importance of concerted action between workers in various countries is better recognized. In the International Commission on Illumination we have an influential body which is itself not very much younger than the subject it studies. Interchange of views and pooling of experience will be an essential feature in the progress of illuminating engineering in the years to come.

The coming Congress will afford an excellent opportunity for experts from all over the world to discuss the technical problems with which they are grappling. But—even more important—it will furnish a unique opportunity of bringing home the important part which the scientific application of light plays in the lives of all of us and of raising the subject to a higher place in the public esteem.

* *The Illuminating Engineer*, November, 1928, pp. 311-313.

General Illumination *Plus* . . .

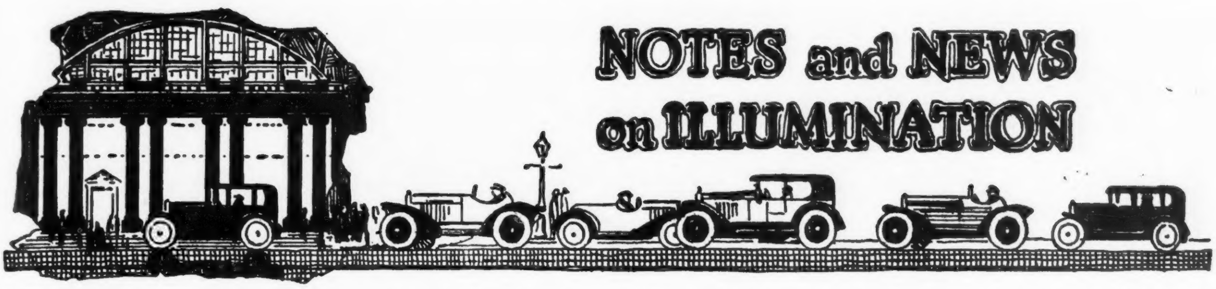
A PAPER with the above intriguing title was read by Mr. M. Luckiesh at the twenty-second Annual Convention of the American Illuminating Engineering Society last year. Its purpose was to emphasize—what most of us have been feeling for some time—the desirability of making frequent use of localized lighting as a supplement to general lighting. Naturally this does not mean a return to the unsatisfactory methods of "local pendant lighting" common in the past. The local lighting which is now proposed is intended to supplement general illumination, notwithstanding the fact that the latter now attains values very much in excess of those prevalent a few years ago.

We have seen a progressive advance in values of general illumination. Three or even five foot-candles is now coming to be regarded as a minimum. Ten to twenty foot-candles is becoming quite usual in this country, and in the United States even higher values are recommended. General illumination of such intensities naturally involves a considerable increase in expenditure on lighting. Yet it cannot be said that even 50 foot-candles will suffice for every purpose. In particular, the influence of the reflecting power of the material treated needs consideration. In extreme cases, such as the handling of dark cloth in the garment-making industry, the brightness of material receiving, say, 50 foot-candles might be equivalent to only 3 foot-candles on a white surface.

A further point to be considered is that the brightness of very dark objects illuminated by general lighting will probably be less bright than the surroundings—whereas it is a sound principle that the material worked upon should be the brightest object in the field of vision. For this reason local illumination, which enables very high illuminations on the work to be readily obtained without the surroundings being lighted to a similar intensity, appears to have advantages both from the psychological and the economic standpoint.

Other considerations of moment are that the degree of diffusion of the light and the direction from which it comes should often be adapted to some special process, e.g., in examining the texture of more or less rough surfaces; that a high illumination on a vertical surface may sometimes be necessary, and it is difficult to furnish this by general lighting methods without a certain degree of glare; and that in certain varieties of work light of special colour may be desirable. All these requirements can be met most readily by some form of local lighting.

Mr. Luckiesh therefore anticipates that special local lighting will be increasingly used to supplement even the high general illuminations now coming into use. In determining the desirable illumination the guiding considerations are "How much do you want to see, and how?" and "How much is it worth to you to see?" In certain forms of fine work illuminations of 100 foot-candles or more may be necessary. There is no great difficulty in furnishing this illumination by local means; but, in this country at any rate, it is only in exceptional cases that a consumer would consent to the expenditure necessary to provide general illumination of this intensity. The provision of moderate general illumination, in addition to high local illumination, is an essential in order to avoid excessive contrasts in brightness, such as are fatiguing to the eyes. In practice this should present no difficulties—especially as, in all probability, the limit of contrast that causes ocular discomfort tends to rise when higher illuminations are used.



The Illuminating Engineering Society

PROGRESS DURING THE PAST SESSION.

As we go to press we learn that the Annual Meeting of the Illuminating Engineering Society has now been fixed for June 4th, the original date having been deferred so as to avoid the distracting effects of the General Elections. By the time this issue appears the annual report of the Council will be in the hands of all members. There can therefore be no harm in forecasting that it will contain evidence of encouraging progress, especially in regard to the financial position, as shown by the accounts for the past year. Following the presentation of the report, an interesting address by Dr. J. F. Crowley is promised. Some members of the Society will recall the very striking demonstrations given by Dr. Crowley some years ago, illustrating the use of synchronously intermittent light to cause fast-moving machines to appear "standing still." We understand that the experiments on this occasion are likely to be even more interesting, and we hope that a good number of members and friends will assemble to witness the demonstration.

The Wembley of the North

We give elsewhere a brief account of the lighting at the North-East Coast Exhibition, which we hope to supplement by illustrations in our next issue. This "Wembley of the North," as it has been termed, seems to be proving highly successful. We are glad to observe that a special feature has been made of illumination, which will doubtless come to be regarded more and more as a valuable aid to those responsible for exhibitions of all kinds. In this case one of the most noteworthy features has been the liberal use of coloured flood-lighting. The opportunity of bringing home to the public in the North of England the possibilities of spectacular lighting has not been lost, and the idea of arranging such exhibitions at leading provincial centres is an excellent one.

A Patents Committee

The President of the Board of Trade has appointed the following Committee to report whether any, and if so what, amendments in the Patents and Designs Acts, or changes in the practice of the Patent Office, are desirable:—

The Right Hon. Sir Charles H. Sargant (Chairman), Mr. Horatio Ballantyne, Mr. H. A. Gill, Mr. E. H. Hodgson, C.B., O.B.E., Sir Herbert Jackson, K.B.E., F.R.S., Mr. W. S. Jarratt, Mr. Fearnley Owen, Mr. J. G. Weir, C.M.G., C.B.E., and Mr. James Whitehead, K.C., with Mr. R. W. Luce, Patent Office, 25, Southampton Buildings, Chancery Lane, W.C.2, as Secretary. Sir Charles Sargant was formerly a Lord Justice of Appeal. Mr. Ballantyne is a managing director of Lever Bros. Ltd., and an expert in patent matters. Mr. Gill is a past President of the Chartered Institute of Patent Agents, and was a member of the Dating of Patents Committee, 1927. Mr. Hodgson is principal Assistant Secretary, Establishment Department, Board of Trade. Sir Herbert Jackson is Director of Research, British Scientific Instruments Research Association, and Emeritus Professor of Chemistry, University of London. Mr. Jarratt is Comptroller of the Patent Office. Mr. Owen is a solicitor and member of the firm of Faithfull, Owen & Fraser. Mr. Weir is a director of G. & J. Weir Ltd., Glasgow. Mr. Whitehead was chairman of the Dating of Patents Committee, 1927.

Ultra-Violet Ray Treatment at a School Clinic

A contribution to *The Medical Officer* by Dr. E. H. Wilkins, Assistant School Officer in Birmingham, seems to us to bear out the remarks made in our last issue regarding treatment with ultra-violet light.* Of 148 cases treated (chiefly for debility, anæmia, bronchitis and asthma) 66 are stated to have shown great improvement, 56 were improved, 16 slightly improved, and only 10 showed no improvement. When figures such as these are presented the onlooker is naturally disposed to believe that the treatment must be of value, even if, as Dr. Wilkins freely admits, the improvement is greater when the treatment is aided by other methods of improving general conditions of health. Of special interest, in view of the prevalence of these disabilities in this country, is the good effect recorded in the cases of asthma and bronchitis. It is sometimes assumed that it is only the very weakly who benefit from treatment with ultra-violet rays, and that the health of such subjects could be improved with equal ease by ordinary measures. The author, however, has found that the children of the very poor, whose dietary is of inadequate quality, improve less quickly, and the improvement gained is apt to be lost when radiation is discontinued. Further, the poorly fed child cannot bear so much exposure as the more robust and well-nourished. This experience serves to emphasize the need for discretion in applying light treatment, which should be pursued under competent medical advice. On the other hand, all of us may benefit in a natural way from the efforts of that great physician, the sun, whose aid we have been gratefully experiencing during the past month.

Association of Public Lighting Engineers

We have now before us the programme of the sixth annual meeting and conference of the Association of Public Lighting Engineers, which is to take place in Bournemouth during September 9th–12th. On the opening day there will be a reception by the Mayor of Bournemouth. On Tuesday visitors will be entertained to luncheon by the Chairman and Directors of the Bournemouth Gas and Water Co. at the Town Hall. The Association dinner will take place in the Town Hall on Wednesday evening. There is to be, as usual, a display of lamps and apparatus for public lighting, and we understand that an interesting programme of papers is being arranged. Bournemouth, needless to say, furnishes a pleasant meeting place, and excursions to the New Forest, the Isle of Wight, Corfe Castle, etc., should add to the enjoyment of visitors.

Lighting on the Underground Railways

We have been interested in observing the emergence from chaos of the concourse at Charing Cross and St. James's tube stations, where notable improvements are being made. An interesting feature at the latter station is the introduction of the cylindrical diffusing light fittings previously adopted at the new Piccadilly Underground Station. This sets a somewhat new note in station lighting. The effect is soft and pleasant, though it might perhaps be contended that the fittings should be octagonal in section, so as to harmonize with the pillars.

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* *The Illuminating Engineer*, May, 1929, p. 107.

The Lighting of Operating Theatres

Some further suggestive notes on the lighting of operating tables in hospitals were given in a paper entitled "Light as an Aid to Surgery," presented by Mr. H. L. Logan at the twenty-second Annual Convention of the Illuminating Engineering Society (U.S.A.). He confirms the impressions of other American contributors, summarized in recent issues of this journal, that an illumination of the order of 1,000 to 1,500 foot-candles is desirable, in view of the low reflecting power of the material and of the fact that the light must enter cavities made by the surgeon's knife. A further point of importance is that most incisions are made parallel with the muscles, in order to avoid muscular rupture, and therefore extend mainly up and down the body. (The author believes that there is only one major operation that requires a trunk incision at right angles to the trunk.) Hence flux of light should be massed along the main axis of the operating table in order that the highest percentage may penetrate a wound. Diagrams showing an illumination along the centre line of 1,400 foot-candles, diminishing to less than 200 foot-candles two feet away, are shown in the original paper. In order to avoid troublesome shadows good diffusion of light is highly important. This may be attained either by using multiple sources or by spreading the light over a single large area. However, the problem is affected by specular reflection from fluids oozing from the tissues. Multiple images from a number of sources are apt to be formed, but the reflection is less troublesome when light comes from one large overhead continuous surface. An even better method, probably, is to arrange this luminous area in a series of panels, separately controlled. Certain panels are then put into use according to the nature of the operation.

The Psychological Aspects of Illumination

At the International Congress of Applied Psychology, recently held in Paris, a paper was read by Mr. A. Auneau emphasizing the important mental influences that can be exercised by illumination. Good lighting has many reactions, which are not always sufficiently appreciated by consumers. If large cities are well illuminated, and efforts are made to reveal monuments and objects of interest by night they will have more visitors. If shops are well lighted their attracting power is increased and they sell more goods. Electrical engineers, architects and users of light should collaborate in making the best use of artificial light to their common advantage.

Arterial Road Lighting in the Riviera

The lighting of various arterial routes in the Riviera district, through which a constant stream of high-speed motor traffic passes, has recently been receiving attention. We notice in *Lux* a quotation from *l'Eclaireur de Nice*, relating to the route from Cannes to Antibes. Three fatal accidents occurred within a fortnight, all due to the dazzling effects of powerful motor-car headlights, are reported. It is pointed out that the effective remedy lies in better public lighting, which would render the use of such brilliant headlights unnecessary. This, it is stated, has already been effected on the portions of the route between Antibes and the Golfe Juan, where modern lighting has recently been introduced, and it is contended that similar methods ought to be adopted throughout all arteries of traffic connecting main towns.

Festival Lighting in Prague

By the courtesy of the Spravni rada Elektrickych podniku hlavniho mesta Prahv (Electrical Enterprises of the City of Prague) we have received some charming photographs illustrating the special floodlighting inaugurated in that city on the occasion of the recent celebration of the tenth anniversary of the Czechoslovak Republic. These illustrations, which will appear in our next issue, relate to the old Town Hall and various churches of architectural distinction, and show how effective floodlighting may be in rendering a city picturesque and attractive by night. We have here yet another example of the Continental tendency to make use of special floodlighting on festive occasions. The idea of using light on occasions of national rejoicing is of very ancient date, but we have now progressed beyond the somewhat crude methods of outlining buildings and devices with coloured lights, customary in the past. The modern method of using concealed lighting is capable of much more artistic effects, and we believe that it will be regularly applied to buildings of distinction in most of the leading cities of Europe in time to come.

Illumination in Italy

We notice in *Illuminotecnica*, the new journal dealing with illumination recently published in Milan, a leading article pointing out the possibilities of illumination as an art and as a decorative medium. Another article deals with the cost of industrial accidents, a substantial proportion of which, in the belief of Sig. F. Massarelli, might be traced to inadequate illumination. The author also quotes from the familiar statistical data prepared by Mr. R. E. Simpson, of the Travellers' Insurance Co. in the United States. There are also contributions illustrating fundamental laws of illumination, and a list of papers read at the International Illumination Congress in the United States is given. It is evident that illumination is now being actively studied in Italy. We have before us a special treatise on the subject recently published by Sig. Guido Peri, which will be reviewed in this journal very shortly.

Illuminating Engineering Society (U.S.A.)

TWENTY-THIRD ANNUAL CONVENTION.

This Annual Convention is to be held in Philadelphia during September 24th–27th. Papers to be presented will constitute a summary of progress in lighting during the past year. A special feature will be the celebration of "Light's Golden Jubilee," i.e., the invention of the electric incandescent lamp. In the Longwood estate of Mr. Pierre S. Dupont will be seen an electric fountain, said to be the most beautiful example of "under-water" illumination in the world.

International Regulation of Motor Car Headlights

We notice in *Licht und Lampe* (May 16th) an instructive survey by Dr. F. Born of the motor-car headlight problem. The author summarizes the views expressed in different countries regarding such points as the nature of the driving beam, methods of dimming, depressed beams, etc., the influence of mist and rain on performance, and the method of testing compliance with regulations. These data are assembled in tabular form, and the note should be of considerable use to those interested in this problem.

TECHNICAL SECTION

COMPRISING

Transactions of The Illuminating Engineering Society and Special Articles

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

The Manufacture and Properties of Glass and their Application in Illuminating Engineering

(Proceedings at the meeting of the Illuminating Engineering Society, held in the Lecture Theatre of Holophane Ltd., Elverton Street, Westminster, S.W.1, at 6-30 p.m. on Tuesday, April 30th, 1929.)

A MEETING of the Illuminating Engineering Society was held in the lecture theatre of Holophane Ltd. (Elverton Street, Westminster, S.W.1) at 6-30 p.m., on Tuesday, April 30th, the chair being taken by the President (Mr. C. C. Paterson).

The minutes of the last meeting having been taken as read, the HON. SECRETARY read out the names of the following applicants for membership:—

Ordinary Members—

Boucher, A.................Managing Director of Messrs. Arnold Stevens & Co., 7, Buchanan Buildings, Holborn, London.

Read, Harold E. T.....Messrs. Tredegars Ltd., 17, Shipley House, Larkhall Estate, Clapham, London, S.W.

Smith, Major P. A., O.B.E., Chief Engineer, Messrs. Drake & Gorham, 16, The Mall, Surbiton, Surrey.

Taylor, L. G.............Lighting Engineer, 17, King Street, Southall, Middlesex.

The names of applicants presented at the last meeting* were read again, and these gentlemen were formally declared members of the Society.

The PRESIDENT then called upon Dr. S. ENGLISH to read his paper entitled "Some Further Properties of Glass and their Application to Illuminating Engineering."

Dr. S. ENGLISH, in his opening remarks, recalled the paper read by him before the Society last year, which dealt mainly with the properties of glass in relation to direction and distribution of light. He had subsequently received numerous enquires bearing on other properties such as heat-resisting power and durability, and he had been asked to deal with these in a supplementary paper. The author then proceeded to discuss the causes of the breakage of glass. He remarked that the breakage of glass in use is less frequent than in pre-war days. Glass may break spontaneously owing to excessive internal stresses, and the author performed several instructive optical experiments showing how readily such strain could be produced. A considerable portion of the paper was devoted to thermal endurance, a property of importance in illuminating glassware. Methods of calculating and testing this quality were described, and particulars were given of recent improvements in composition and manufacture which have given rise to greater heat-resisting power. In conclusion the important question of durability was discussed. It was pointed out that the introduction of soda, which renders glass easy to work and handle, is very liable to reduce the durability. A method of testing durability was illustrated, and some data were presented to show the great improvement secured in the case of several varieties of glass of recent introduction.

**The Illuminating Engineer,* April, 1929, p. 96.

The paper gave rise to an interesting discussion, in which the following took part: Dr. WM. HAMPTON, Mr. D. R. WILSON, Dr. J. W. T. WALSH, Lt.-Commander HAYDN T. HARRISON, Mr. F. W. HODKIN, Mr. N. SHELDON and Mr. W. R. RAWLINGS. After Dr. English had briefly replied to the various queries, a very cordial vote of thanks was proposed by the PRESIDENT, who remarked that the paper contained evidence of the very considerable amount of research that was now going on in connection with glass manufacture and of the spirit of enterprise that was now being developed in this old-established industry.

In concluding his remarks the PRESIDENT proposed a very cordial vote of thanks to Dr. S. English for his interesting and instructive paper, to Holophane Ltd. for their hospitality, and to Mr. R. Gillespie Williams for the series of demonstrations of effects of coloured light which they were now about to witness.

It was also announced that the next meeting would be held in the lecture theatre of the Home Office Industrial Museum, at 6-45 p.m. on May 14th, when a paper reviewing the proceedings at the International Illumination Congress held last year in the United States would be read by Mr. G. H. Wilson.

Most of those present then adjourned to the Holophane laboratories, where they witnessed a striking demonstration by Mr. R. GILLESPIE WILLIAMS of effects of coloured light. The demonstration was on lines generally similar to those followed in the display given to members of the Society in 1927, but there were some novel features. The application of colour lighting as a supplement to kinema displays was again illustrated, and numerous striking demonstrations of the influence of changing coloured light in completely altering the appearance of dresses, scenery, wallpapers, etc., were given. (A fuller account of this demonstration will be found on p. 142.)

Annual General Meeting

We learn that the date of the Annual General Meeting of the Illuminating Engineering Society has been deferred, owing to the general election.

This meeting will take place in the House of the Royal Society of Arts (18, John Street, Adelphi, London, W.C.), at 6-30 p.m. on Tuesday, June 4th. After the presentation of the Report of the Council for the past session, an address, illustrated by demonstrations, dealing with some further applications of synchronously intermittent light for revealing moving machinery will be given by Dr. J. F. Crowley.

The Manufacture and Properties of Glass and their Application in Illuminating Engineering

By S. ENGLISH, D.Sc., F.I.C., F.Inst.P.
(*Research Department, Holophane Ltd.*)

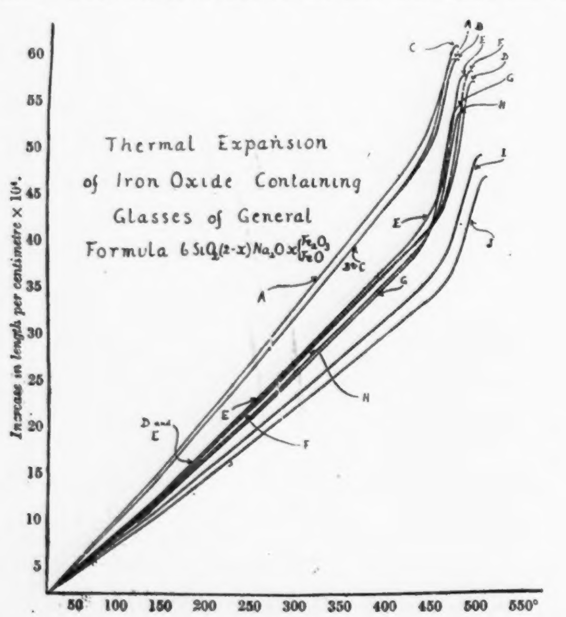
(*Paper presented at the meeting of the Illuminating Engineering Society, held in the Lecture Theatre of Holophane Ltd., Elverton Street, Westminster, S.W.1, at 6-30 p.m. on Tuesday, April 30th, 1929.*)

LAST year, when I had the honour of addressing this Society on the Manufacture and Properties of Glass and their application in illuminating engineering, I explained that the subject was so wide that only a small section could be dealt with in one paper, and, as you may remember, I then dealt chiefly with those properties such as light transmission, colour and dispersion, which are of direct importance in lighting work. That illuminating engineers are interested in other properties of glass was shown by a number of questions that I had the pleasure of answering briefly on that occasion. In the present paper, I wish to answer some of those questions more fully, and at the same time to illustrate my remarks by giving actual experimental data showing how a glass, in which I am particularly interested, has been improved in those respects under consideration.

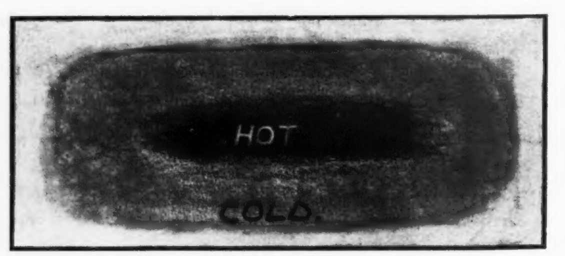
More than one question asked at that meeting concerned the breaking of glass in use. Some people may look upon this as an inherent defect in glass, but though one must admit that glass is somewhat brittle, in so far as it is incapable of bending to any marked extent except when it is rather thin, still it must be remembered that glass can be made exceptionally strong. In fact, it may be claimed as an advantage for glass, that when intelligently handled its mechanical strength can be controlled so as to meet any reasonable requirements.

On the other hand, it must be admitted that glass does sometimes break while in use, though it will probably be agreed that failures in this respect are much less frequent now than they were in pre-war days. As it is from a study of failures that we can learn most, I ask that, in giving prominence to defects and failures, you will not assume that I am at all pessimistic regarding the use of glass by illuminating engineers. As a matter of fact I am an incurable optimist.

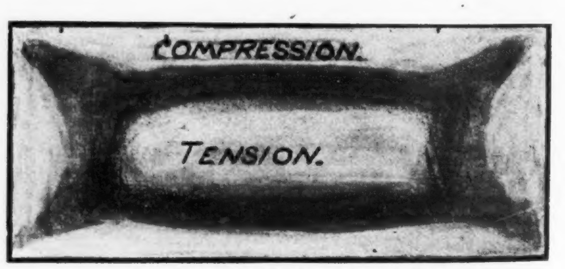
In attempting to study the failure of glass by fracture, it is obvious that two distinct cases present themselves; the glass may break spontaneously or it may be broken by external means. Spontaneous breakage is caused by the presence of an excessive internal stress within the glass itself. Such stress is due to the fact that glass has to be formed into the desired shape at very high temperatures—generally between 1,200° and 800° C.—and at the completion of the forming process it is still red-hot. In cooling from these high temperatures, glass naturally contracts, and here two unfortunate circumstances come into play. First, glass is such a poor conductor of heat (.001 to .0024, as against 1.0 for copper) that unless very great care is taken the temperature throughout the formed glass article does not become uniform and some parts may "set" before others. Secondly, in cooling down, glass suffers a very marked contraction on passing through what may be called the annealing range, as shown by the curves in Fig. 1.* It is evident, then, that if one portion of a piece of glassware (say the outside) passes through this setting zone before an adjacent portion (say the interior) reaches it, then the outside has become rigid while the interior still has to pass through this zone of increased contraction. When such a glass has reached the ordinary temperature the centre portions are in a state of tension, while the outer zones are in a state of compression, and there are naturally neutral zones in between the stressed regions. Such a stress distribution can easily be shown by examining a rectangular block of glass such as an ordinary pavement prism in an apparatus known as a strain viewer similar to that designed and described by the author in 1919.† In this apparatus, unstrained glass or neutral zones show up as dark areas while strained zones show up as bright patches (Fig. 2). If the strain is very severe, then these bright patches become coloured. This instrument can be used to examine the state of annealing of any transparent glass, though in certain cases it is advisable to use auxiliary appliances to render it more suitable for special circumstances; e.g., a plate of quartz, mica or selenite may be included in the eyepiece to enable strain to be detected by colour changes instead of by brightness changes.‡ (At the meeting the author conducted experiments illustrating the appearance of (1) a cube of glass and (2) a strained electric lamp pinch with sealed-in wires when this colour change method is used.)



Temperature.
FIG. 1.



(*a*) Temperature Distribution on Cooling.



(*b*) Stress Distribution when Cold.
FIG. 2.

* English, Howes, Turner and Winks, J.S.G.T., 1928, *12*, 31.
† English, J.S.G.T., 1919, III, 258.
‡ Twyman, J.S.G.T., 1917, I, 61.

It is obvious that if the strain left in a piece of glassware is excessive when compared with the strength of the glass itself, then fracture may be expected, but a peculiar feature of such fracture is that it may occur immediately after or even during the cooling of the glass to the ordinary temperature, or it may be delayed for days, months or even years. (I have known a tumbler, after 13 years' use, fracture while standing untouched on a shelf, and one of the tumblers which has been in regular use at home during the last two years very conveniently —for the purpose of demonstration—fractured in exactly the same way while this paper was being written.)

Another feature of such strain cracks is that they often, though not always, follow some prominent contour of the form of the article; e.g., in the tumblers referred to above, complete rings were split off from the top about ⅜ in. deep, almost as cleanly as if they had been cut off.

In pre-war days such fractures as these were fairly frequent, but during the past 15 years a great deal of experimental research work has been done both in this country and in America,* with the result that we now know very much more about the annealing process than was known then. This experimental and theoretical knowledge has been used to good effect by designers and suppliers of glass works equipment, so that, by using modern plant, a glass manufacturer can be absolutely certain of getting well annealed glass continuously—a state of affairs which the pre-war glass manufacturer would have looked upon as Utopian. Certain of these lehrs have been designed on theoretical considerations, with a result that perfect annealing of ordinary-sized glassware under favourable conditions can be carried through in as short a time as 1 to 1½ hours, whereas 15 years ago as much as 8 hours was often given to this process and even then the annealing was very often unsatisfactory.

Turning now to the breaking of glass by external influences, it is clear that so far as the illuminating engineer is concerned the most important factor which has to be considered is the capability of glass to withstand high temperatures and changes of temperature, i.e., thermal endurance. This property is of prime importance to those who use gas as an illuminant, since the heat produced by modern burners is considerable, especially so in the case of high-pressure and superheated burners so often used in street lighting installations. To the engineer using electricity, this question of thermal endurance of glass is becoming more and more important, for the modern gas-filled lamp radiates much more heat than the older vacuum type of lamp, and, further, the present tendency to reduce the size of lamp bulbs for standard wattages may call for still better heat-resisting illuminating glassware, for it is clear that these smaller lamp bulbs are going to get hotter than the rather larger ones that they are replacing, and also it will be possible though not advisable to use a higher wattage lamp in a fitting than that for which it was designed.

Besides this resistance to high temperatures and temperature changes, of course, a certain mechanical strength is required to withstand accidental blows, but fortunately this property is so closely allied to the power to withstand temperature changes that it need not be considered separately.

It is obvious that thermal endurance is a very complex property since it depends on, or is a function of, so many other properties. Winkelmann & Schott† have investigated this property both theoretically and practically, and have shown that the thermal endurance of a glass may be calculated from its simpler properties by the following equation $F = \frac{P}{a E}\sqrt{\frac{K}{s.c.}}$ where F = thermal endurance. P = tensile strength. K = thermal conductivity. a = linear thermal expansion. E = Young's Modulus. s = density and c = specific heat.

Using this equation, the thermal endurance of a number of glasses was calculated, and, the results compared with the sudden fall of temperature required to cause fracture of polished cubes of the same glasses. The theoretical calculation and the practical experiments placed the glasses in approximately the same order, as indicated by a selection of the results set out in Table I.

TABLE I.

COMPARISON OF CALCULATED AND EXPERIMENTAL THERMAL ENDURANCE.

Glass No.	Calculated F.	Temperature difference causing fracture. 2 cm. cube.	Temperature difference causing fracture. 1 cm. cube
21	12.30	110.5	148.0
5	10.68	95.5	—
25	9.69	78.5	103.5
28	6.96	77.8	88.4
26	6.72	69.8	88.5
33	5.88	65.8	87.0

These figures serve to show that the resistance of glass to fracture on sudden chilling could be varied considerably, even as far back as 1894, by modifying the composition of the glass, but to-day we have a few glasses which are much more resistant to thermal changes than those referred to in Table I.

Stott‡ has recently put forward a simpler formula for the calculation of thermal endurance, namely:

$$T_1 - T_0 = \frac{P\ (1-\sigma)}{E\,a}, \quad \text{where}$$

$T_1 - T_0$ = temperature difference causing fracture.
σ = Poisson's ratio.

This equation gives calculated results agreeing slightly better with the experimental data than does Schott's formula.

Both the formulæ suggested for the calculation of thermal endurance indicate that the chief factors which go to make up this complex property are the tensile strength, coefficient of expansion and the elasticity. Fortunately, we now know how to control our glass compositions so as to produce any desired change (within limits) in each one of these three factors, but unfortunately it is seldom possible to alter any one property without, at the same time, affecting the other properties of the glass—perhaps in an undesired direction.

It is therefore absolutely essential for a glass technologist, when contemplating a change in his glass composition to improve any particular property, to consider the effect of the proposed change on *all* the properties of the glass; e.g., an ill-considered attempt to improve the thermal endurance may lead to the production of a glass which does not melt satisfactorily, or which cannot be worked by the desired process, or which cannot be annealed by the equipment available, and, even if these obstacles are overcome, it may have a bad colour or it may not be resistant to atmospheric corroding influences. This is evidently a complex matter, and it therefore, perhaps, may be best to deal in some little detail with one particular example.

IMPROVEMENT IN PRISMATIC GLASSWARE.

THEORETICAL CONSIDERATIONS.

It was mentioned in the previous paper that the glassware developed by the company with which I am associated is made by pressing plastic glass between a mould and plunger, in just the same way that ordinary pressed tableware, etc., is made. Up to two years ago, such glass in this country was made of a composition which might be looked upon as typical of pressed tableware, namely, 72.0 per cent. SiO_2, 6.4 per cent. CaO, 0.5 per cent. Al_2O_3, 19.9 Na_2O, and minor constituents.

This composition melted quite easily and quickly into a clear colourless glass at temperatures between 1,350 and 1,400° C., and was particularly easy to press into complicated shapes without cracking across the edges, since it had a long working range.

From these two points of view this glass was perfectly satisfactory, and little more need be asked for table-

* See Twyman, *loc. cit.* English and Turner, J.S.G.T., 1918-28. Adams and Williamson, *J. Franklin Inst.*, 1920, *690*; 597 and 835. Hampton, *Trans. Opt. Soc.*, 1924-25, *26*, 14; and 1925-26, *27*, 161.

† Winkelmann and Schott, *Ann. der Phys. und Chem.*, 1894, *51*, 730.

‡ J.S.G.T. 1924, *8*, 139.

ware, but the modern demands on illuminating ware for use in this and tropical countries made it advisable to seek to improve two properties—thermal endurance and resistance to atmospheric corrosion—without detracting more than necessary from its easy melting and working properties. At the same time that these changes were being made, it improvements could be made in such properties as purity of colour and brilliance, so much the better.

It will be remembered that the three most important properties involved in the thermal endurance are α—expansion, E—elasticity and P—tensile strength.

It has been shown by Winkelmann and Schott that the value of these properties can be approximately calculated for a glass, on the assumption that each 1 per cent. of each constituent oxide has a specific effect which can be denoted by a number, e.g.:—

Coeff. Exp. $= ax_1 + bx_2 + cx_3$
a, b, c, = percentages of different oxides
$x_1, x_2, x_3,$ = factors for the several constituents.

Table II gives these factors for the three properties under consideration for the chief glass-making oxides which may be considered as useful for the present purpose.

TABLE II.

FACTORS FOR CALCULATING PROPERTIES.

Oxide.	Expansion.	Elasticity.	Tensile strength.
SiO_2	0.05 ($\times 10^{-7}$)	65	0.09
CaO	1.63 ,,	100	0.20
Na_2O	4.32 ,,	100	0.02
B_2O_3	−0.66 ,,	20	0.065
Al_2O_3	0.14 ,,	160	0.05
ZnO	0.70 ,,	15	0.15
BaO	1.43 ,,	100	0.05

(Expansion factors are taken from recent work by English and Turner. Elasticity and strength factors from Winkelmann and Schott.)

Remembering that the thermal endurance is proportional to the tensile strength, it appears from Schott's figures that lime, zinc oxide and boric acid are the most favourable and soda the least favourable constituents from this point of view. As the result of more recent work on the mechanical properties of glass Gehlhoff and Thomas* conclude that the most effective constituents for promoting strength in glass are lime, boric oxide and alumina, and that zinc oxide comes quite low down in the list; even below soda. For reducing the expansion, boric oxide, silica, zinc oxide and alumina are best, and soda is most detrimental. Boric acid and zinc oxide are again useful in bringing down the elasticity, and soda, lime, baryta, and particularly alumina, appear to be harmful.

Summing up these individual effects from the point of view of thermal endurance, it appears that boric oxide, silica, lime and perhaps alumina and zinc oxide are likely to be most useful, while soda is likely to be most harmful. The question then arises as to how the above-mentioned glass composition could be modified along these lines, without spoiling the melting and working properties, for it must be remembered that soda is the constituent which provides easy melting and a long working range, while increasing silica, alumina and zinc oxide (to varying extents) cause slower melting, and boric oxide hastens the rate of setting. This increased rate of setting caused by boric oxide is

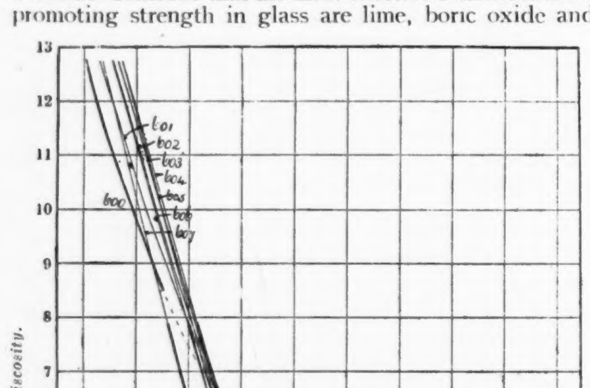


FIG. 3.

Zeit für tech. Physik, 1926, 7, 105.

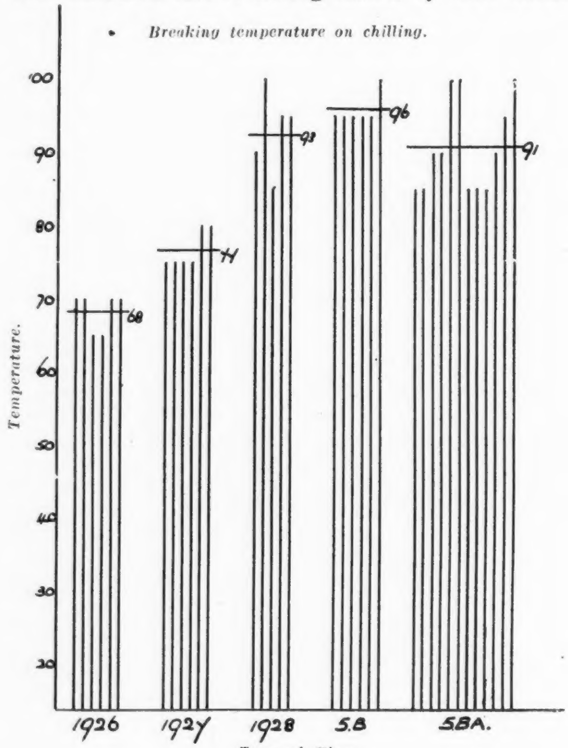


FIG. 4.

clearly shown by the viscosity-temperature curves, reproduced in Fig. 3, for a series of glasses in which boric oxide replaced silica in increasing amounts in passing from No. 600 with no boric oxide to No. 607 with 40 per cent. boric oxide. In view of these facts, it was decided to proceed cautiously, and, with the co-operation of Mr. Davidson, to make small changes at lengthy intervals so as to be sure of keeping the melting within the capabilities of an ordinary well-run pot furnace reaching a temperature of 1,380° to 1,400° C., and also to allow the workmen to become familiar with any small changes in working properties which could not be avoided, and to adapt themselves to meet such changes. In this way it has been possible to obtain a glass composition so different in several ways from the original that, had the changes been made in one abrupt step, it is certain that the workmen would have had difficulty in coping with it; in fact, it is quite likely that they might have found it impossible to work without serious loss of production.

METHOD OF TEST AND RESULTS.

For the testing of these modified glass compositions, the method of determining the thermal endurance of illuminating fittings put forward in B.E.S.A. Specification No. 324, 1928, is not sufficiently precise, and as the glass itself, as distinct from a unit made of it, was under investigation a more quantitative method was

employed. After a preliminary examination for good annealing and freedom from manufacturing defects, what we call E.60 reflectors were immersed in a bath of hot water at 60°C. for three minutes and then very quickly transferred to an adjacent bath of cold water maintained at 15°C. If fracture did not occur, the temperature of the hot bath was raised 5° and the process repeated and so on at 5° intervals until failure did take place as a result of the sudden chilling. E.60 reflectors made from the glass composition already given, and which we may call D 1926 glass, generally fractured in this test at 65 or 70°, the average of a particular batch of 6 being 68°; i.e., at a temperature drop of 53° (Fig. 4).

The first change in composition made in 1927 was in the direction of reducing the alkali content and increasing the proportion of lime. This had a small effect in raising the average breaking temperature to 77°, i.e., a temperature interval of 62°. In the early months of 1928 a further series of modifications was made, again reducing the alkali content and this time adding increasing quantities of boric oxide. In this way the average breaking temperature was gradually raised to 92.5—the corresponding temperature drop being 78.5°. In January and February, 1929, further small alterations were made, reducing the alkali content still further and increasing the boric oxide and alumina figures.

One trial composition, 5BA, gave interesting results; two out of six reflectors fractured at 100-15° only on second immersion, two broke at 90-15° and two at 80-15°. A second melt of this same composition gave similar irregular results, and for this and one other reason, to be mentioned later, this composition could not be adopted.

Six reflectors, from another of these trials, 5B, when tested in the usual way gave very good figures, all withstanding temperature falls from 90-15°, five of them fracturing at 95-15° and the remaining one at 100-15°, a remarkably consistent set of results with an average chill of 81°, representing a 50 per cent. improvement when compared with the 1926 glass. Further tests on reflectors made from other melts of this particular composition also gave uniformly good results. The whole of these results are set out in diagram form in Fig. 4.

A comparison of the more important primary properties based on theoretical calculation is given in Table III, from which it is seen that the coefficient of expansion of the new glass is distinctly less than that of the 1926 glass, but the tensile strength is higher. By calculation, the thermal endurance of the new glass should be 40 per cent. better than the old glass—a figure quite close to the experimentally found value, especially when one considers the very complex nature of this property.

TABLE III.

CALCULATED VALUES OF VARIOUS PROPERTIES.

Glass.	Tensile strength.	Coefficient of expansion.	Coefficient of elasticity.
1926	8.18 kg./sq.mm.	.00001003 per °C.	7396 kg./sq.mm.
5B (1929)	8.54 ,,	.00000832 ,,	7156 ,,

In this new glass, although the silica content has been increased to 73.3 per cent., the soda content has been reduced to 16.2 per cent., but in spite of this the glass melts within the time that the glass maker can allow, without disturbing the routine of his shops, and it still retains the easy clean pressing properties which are essential for the proper formation of reflecting and refracting prisms. This composition has now been adopted as standard for our ordinary illuminating glassware, and the improvement embodied in it is one which illuminating engineers should appreciate, since it gives them a much bigger margin of safety. In spite of this 40 per cent. to 50 per cent. improvement, no false claims are being made for this glass; it cannot be regarded as a full heat-resisting glass, but should rather be looked upon as a semi heat-resistant glass, and should be used as such.

HEAT-RESISTING GLASSES.

For many purposes, however, much more resistant glasses are necessary. For example, a recently designed refracting plate for use in street gas lanterns, many of which now use either high pressure gas or superheating burners, must necessarily be made of glass which can successfully withstand high temperatures and severe temperature gradients from the mid zone to the ends. The glass for these plates has been produced in another factory by working along the lines already mentioned, and decreasing the soda content of the glass to approximately only 8 per cent. Of course, this glass melts and works very differently from the ordinary glass. It requires a much higher temperature to bring it to a bubble-free condition—it must be worked at a high temperature and rather quicker, since it has a fairly rapid rate of setting. It also anneals at a distinctly higher temperature. The coefficient of expansion of this glass has been reduced to the neighbourhood of .000005 per °C., while its tensile strength has been increased to 8.78 kg/per sq. mm. On being tested for thermal endurance as above, this glass (which has been called "Bozal") generally withstands chilling from 120 to 15°, but fractures at 130 to 15°, thus showing an improvement of 100 per cent. when compared with the glass previously referred to as D 1926.

The plates made from this glass were designed for use in lanterns with 1, 2, 3 or 4 inverted mantles, but one case has been reported to us of their use with a 12-mantle burner. Although the plate stood up to this treatment it is not recommended that such risks should be taken.

There are a few occasions when the illuminating engineer requires a still more heat-resistant glass; for example, the front glasses of powerful floodlights need to be very resistant to temperature changes. Even the outside of the front lens of one of our new floodlights, when employing a 1,000-watt lamp, reaches a temperature of over 200°C. Now "Bozal" glass will withstand such a temperature satisfactorily, but if water be sprayed on the glass in imitation of a heavy rain storm, when it is at this high temperature fracture often takes place. To meet these conditions it is necessary to have these lenses made of "Pyrex," or a similar glass, which as everyone knows is very resistant to changes of temperature. The composition of this glass is approximately 80 per cent. SiO_2, 12 per cent. B_2O_3, 5 per cent. Na_2O, 2 per cent. Al_2O_3, and its coefficient of expansion is only about .0000033 per °C. If anything more heat-resisting than this is required at the present time, then there is only fused silica with a coefficient of expansion of .0000005 per °C. to fill the need. Unfortunately this substance is exceedingly difficult to melt and work, but during recent years enormous progress has been made in the manipulation of the white-hot material, so that this product can now be obtained in a large variety of forms.

DURABILITY.

Another important property of glass which was mentioned in the discussion of the previous paper is its power to withstand the corroding action of atmospheric agents, or, in short, its durability. In this respect glasses are very variable; the Portland vase is reputed to be of Grecian origin, bottles and plates have come down to us from Roman times, while some of our great Cathedral windows date from the 12th and 13th centuries. The oldest in England is probably that in the choir windows of Canterbury Cathedral which is supposed to date from 1174. On the other hand, some glasses are so easily attacked by the contents of the atmosphere that their surfaces deteriorate appreciably on exposure for a few hours. It follows that the resistance shown by glass towards the attack of corroding agents varies over an enormous range.

Glasses which are easily attacked quickly form a layer of moisture over their surface, with the result that they have a rather greasy feel after they have been exposed to the atmosphere for a time. If nothing worse than this occurred, the illuminating engineer, as distinct from the lamp manufacturer, would not mind much, but unfortunately this collecting of a film of moisture is only the first stage of a complex process which finally results in the formation of a rough opaque skin over the surface of the glass.

The most effective attacking agent in the atmosphere is moisture, but this is strongly assisted by warmth, so much so that glasses which have been found satisfactory here have been quickly corroded by the hot moist climate found in parts of India.

The chief factor which controls the defensive property of the glass is its composition—often quite small variations in composition are sufficient to bring about marked changes in the durability. Unfortunately that constituent of glass which reduces the durability most is just the one which makes for easy melting and working, namely, soda; consequently if the glass manufacturer cares for nothing but output he is tempted to soften his glass, thereby rendering it susceptible to the attack of atmospheric agents. This short-sighted view has often proved disastrous. The most effective constituents for improving the durability are such oxides as boric oxide, alumina, lime, zinc, and silica. It will be noticed that these constituents are just those which were useful previously in the improvement of the thermal endurance. In fact, during the whole of the time that changes were being made in the glass composition, durability tests were carried out side by side with the thermal endurance tests so as to check the effect of each change on both these properties.

The durability tests were carried out in general along the lines which have been developed and used extensively in the Glass Department of the University of Sheffield, but in detail several modifications were made so as to render the method more suitable for commercial, as distinct from precise scientific tests. Since these modifications have not been described elsewhere and since most members of this Society may not be familiar with the method of testing the durability of glass, it may be worth while to describe the process which was used.

In the first place, as moisture is the principal corroding agent that ordinary glass has to withstand, water is naturally used in the tests, although its action on glass is very much slower than the action of solutions of caustic soda, or sodium carbonate.

In order to obtain a measurable attack in a reasonable time when testing glasses with a satisfactory durability, boiling water is used and it is necessary to crush the glass into small grains, so as to expose an enormously increased surface area to the action of the water. Grains of a definite size are used, with a fairly small variation between the maximum and minimum sizes. These are obtained by using only those grains which pass through a 20 I.M.M. sieve and remain on the 30 I.M.M. sieve. In spite of careful and prolonged shaking, it is found impossible to remove all the very fine glass dust from the grains by sieving. It has to be removed by washing. For precise tests as practised at Sheffield, this washing is done in a fine mesh platinum bag by using absolute alcohol and repeating several times, but for the tests under review a quicker and more thorough method is used, though it is open to one minor objection. The grains are transferred to a silica Gooch crucible with holes in the base less than the size of the glass. This is placed in an ordinary glass funnel which is carried in the neck of a filter flask, with its stem passing well down towards the base of the flask. A small air vent is also provided in the stopper. The side tube is connected to the water tap, and a steady stream of water is passed upwards through the glass grains for two minutes at such a speed that they are carried upwards for about half an inch before falling back to their normal level (Fig. 5). In this way every grain is separated from the others and washed in a running stream of water, thus entirely freeing it from any clinging dust. Also if any particles of glass much less that the normal grain size have not been removed by sieving, or if there are any "shattered" grains among the mass, they are washed out by this process. After washing, the grains are placed on filter paper and quickly dried on a hot plate.

In the precise method a weighed quantity of glass is taken, but for the present tests a definite volume is taken by exactly filling a cylindrical brass tube—tall compared with its width, so as to promote accuracy. The size of the cylinder is such as to hold 10 grams of granular glass, and the quantities measured out by it are generally found to be uniform to within 1 or 2 per cent. This quantity of glass grains is replaced in the silica Gooch crucible and placed on a silica triangle with its arms bent down into the form of a tripod within a vitreosil beaker containing 200 c.c. of boiling distilled water. In order to maintain consistently the same rate of boiling for all tests, the usual gas burner is replaced by an electrically heated hot plate. The legs of the silica tripod are of such a height that the water just rises to the level of the top of the glass grains. In the Sheffield method, and indeed in all other published methods, washing of water through the glass grains during the test is not attempted except and in so far as the natural movement of the water causes it to penetrate into the mass of grains. This is admittedly a weakness which has troubled more than one investigator, but in the present method it has been entirely overcome in a very simple and efficient manner. A piece of clear silica tube, 4mm. internal diameter, is flared open at one end or sealed on to a wider piece about 15 mm. diameter. The upper end is turned over and cut short at such a height that when hung over the rim of the Gooch crucible the open flared end is about ¼ of an inch above the base of the beaker (Fig. 6). This tube acts as an automatic pump in the following way,—the tube naturally fills up to the level of the boiling water, then the lower flared end collects rising bubbles of steam which pass into the narrow tube, but the diameter of this tube is such that these bubbles cannot rise by slipping past the water, so they have to raise the column of water above them,

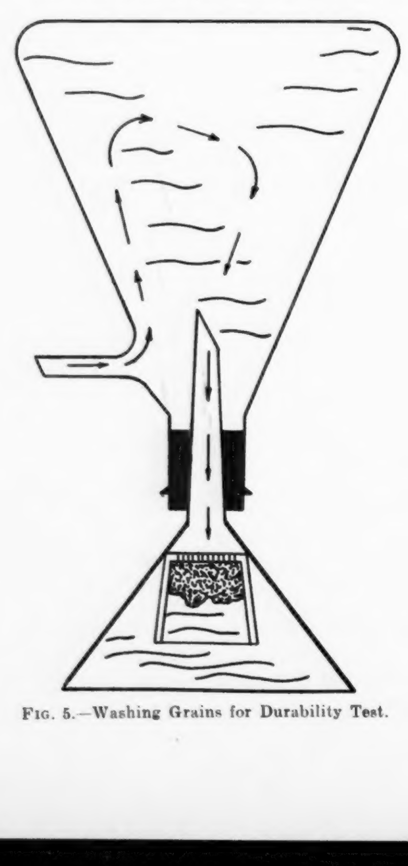


FIG. 5.—Washing Grains for Durability Test.

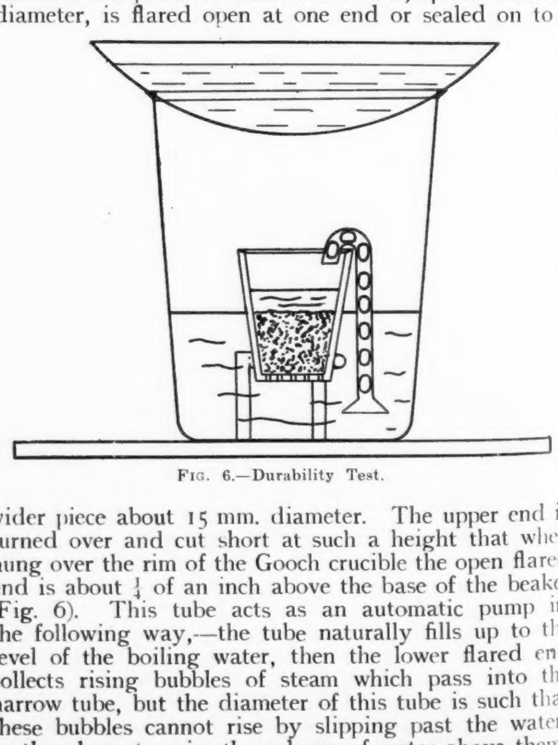


FIG. 6.—Durability Test.

thus forcing it over the bend at the top of the tube and into the crucible. In this way there is a continuous stream of boiling hot water interspersed with steam passing into the crucible, and in spite of the steady flow of water downwards through the glass and out of the base of the crucible the level of the water inside the crucible is always slightly higher than the level in the beaker. Thus are any soluble products of the attack of the water washed away from the glass and a supply of constantly changing water brought up to continue the process.

The test is carried on for one hour, during which time evaporation is prevented by a porcelain dish containing cold water closing the top of the beaker. At the end of this period the grains are lifted above the water level, washed through with distilled water, and then removed. The contents of the beaker are transferred to a clear glass flask and while still hot titrated against very dilute sulphuric acid $\left(\frac{N}{20}\right)$ using Bromthymol blue as indicator, and having a neutral standard at hand to assist in judging the exact endpoint. In this way the amount of soda extracted from the glass is determined. This, of course, is a measure of the attack, and the reciprocal of this figure may be looked upon as a measure of the resistance to attack, or a kind of figure of merit. In Table IV, details of measurements made in the previously mentioned glasses are given, and they are set out in diagram form in Fig. 7.

TABLE IV.—DURABILITIES.

Glass.	$\frac{N}{20}H_2SO_4$	Na_2O.	Figure of merit.
D 1926	15.7 c.c.	.0243 gm.	41.1
D 1927	7.0 ,,	.0108 ,,	92.6
4B 1928	3.5 ,,	.0054 ,,	185
5B 1929	2.9 ,,	.0045 ,,	222
5BA 1929	2.3 ,,	.0036 ,,	278

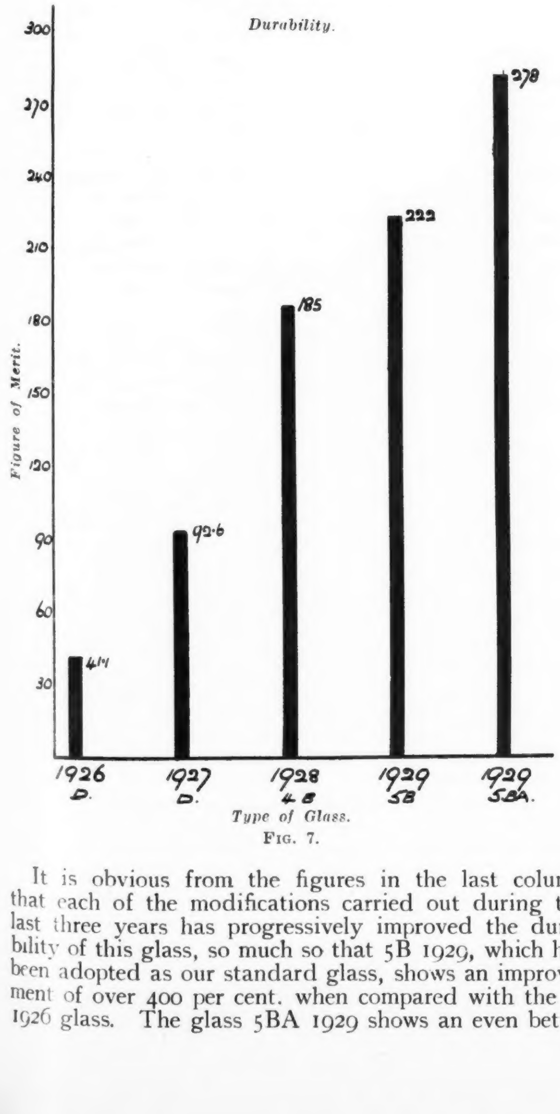


FIG. 7.

It is obvious from the figures in the last column that each of the modifications carried out during the last three years has progressively improved the durability of this glass, so much so that 5B 1929, which has been adopted as our standard glass, shows an improvement of over 400 per cent. when compared with the D 1926 glass. The glass 5BA 1929 shows an even better improvement, but it will be remembered that this glass, when tested for thermal endurance, gave irregular results which were rather inferior to the regular sets given by 5B 1929. Also it was found that the glass 5BA 1929 was not so bright as the others, whereas 5B was a particularly bright glass; in fact, in this particular glass decolorization has been carried out as far as possible by chemical means, so that the amount of manganese dioxide necessary for the physical decolorization was reduced from 14 oz. to 9 oz. per batch. This in itself may not seem an important matter, but it must be remembered that any reduction in the manganese or other decolouring agent added to glass necessarily improves the transparency. When all the data given above are taken into consideration it must be agreed that the glass 5B is a great improvement on the D 1926 and D 1927 glasses in every respect that is of importance to the illuminating engineer.

Discussion

The PRESIDENT (Mr. C. C. Paterson), in opening the discussion, said that many of those present would recall the exceedingly interesting lecture which Dr. English had given in that room last year, when the Society likewise enjoyed the hospitality of the Holophane Company, and many interesting things were shown. He thought they would all agree that the present paper had been equally interesting—(applause)—and he would call upon Dr. W. M. Hampton to open the discussion.

Dr. W. M. HAMPTON said that it was pleasant to congratulate Dr. English on the good work he was doing in educating the illuminating engineer with regard to some of the difficulties which beset the glass manufacturer. It was somewhat ungracious, and much less simple, to criticize him, and he trusted that Dr. English would forgive him if in his remarks he followed the less gracious of these alternatives. When some four or five years ago the question of thermal endurance became important to the company with which he (Dr. Hampton) was associated, it was found necessary to investigate thoroughly both the theoretical and practical sides of the question. They were able to show finally that the temperature difference which an article of a given shape and size would stand was proportional to the product of $P\left(\frac{1-\sigma}{\alpha E}\right)$ and a complex function which involved both the thermal diffusivity and the thickness of the article. They had also been able to show that when the thickness was sufficiently great (which in the case of the articles with which they were concerned was about 5mm.), the temperature difference became independent of the diffusivity and the thickness. For thick articles they found that the temperature difference reduced to the same expression as that given by Stott and which had been quoted that night by Dr. English, and they were able to show that for any other thickness, to a close approximation, the temperature difference to cause breakage was proportional to Stott's figures. He mentioned these facts to show that the calculated figures given by Dr. English did give a very fair guide as to the behaviour of a given glass as compared with another glass when both were made into the same article.

Dr. English had shown that evening that in the course of two or three years he had been able to diminish the coefficient of expansion from approximately 100×10^{-7} to 83×10^{-7}. He had also quoted figures referring to tensile strength and coefficient of elasticity and, on the basis of his (Dr. Hampton's) previous experience, he was able to deduce that a certain article which they had adopted as a standard would break with a temperature difference of 93° in the first case and 122° in the second. So far, so good, but he was then somewhat surprised to find that Dr English referred to the second of these as "semi heat-resistant glass." He was surprised since the glass which was ordinarily used for glazing windows had a coefficient of expansion of only 80 and a thermal endurance figure, on the basis given above, of 143. Therefore, ordinary window glass, as manufactured in this country, was a considerably better heat-resistant glass than Dr. English's ultimate semi heat-resistant glass. If Dr. English really thought that a glass having a

coefficient of expansion of 83 could be called semi heat-resistant then appeared that an excellent opportunity for advertising had been lot, since the glass which was supplied for dioptric lenses, lighthouse lenses, spectacle lenses, and for window glass could all have been advertised as semi heat-resistant

He had no criticism to offer on what the lecturer had said on the question of durability, but he would like to congratulate Dr. English on the characteristic manner in which he had overcome the very considerable difficulties in the determination of durability. He still felt that the glass that Dr. English was using was not entirely satisfactory on the grounds of durability, as in the work he had done he had adopted as a standard that 15 per cent. of soda was the limit for satisfactory durability in the case of soda-lime glasses, though this figure could be modified slightly if the alumina were increased.

He hoped that Dr. English would not take his critical remarks as signifying any lack of appreciation of the valuable work that had been done and was being done, but he felt that Dr. English's remarks on the question of thermal endurance did need a little amplification.

Mr. D. R. WILSON also congratulated Dr. English and said that he had been struck by the remarkable improvement that had been effected in a short time. The last diagram had shown that the figure of merit and durability had been increased something like seven times since 1926. That was a great achievement, and they ought to be proud of the progress that was being made in glass manufacture by means of technical reasearch. The householder generally found that the most important factor connected with fracture was external shock. As a matter of fact fractures were very much less than before the war.

Dr. J. W. T. WALSH said that the lecture had been very interesting and had more than fulfilled expectations. He had been particularly interested in the part of it that dealt with durability. Some years ago he had come up against the problem when serving on a committee that dealt with navigation lights. Few articles were subjected to worse treatment than the lens in front of such lights. The design was appalling from the point of view of durability. Owing to the use of a paraffin lamp the internal temperature of the lantern might be very high indeed. The lantern might be exposed to a strong breeze below freezing point, the atmosphere might be moist, owing to sea spray or it might be tropical. The committee had not been able to prescribe any particular test for lenses that would be so treated. He would like to know whether Dr. English could suggest a durability test for navigation lenses that could be applied without destroying their usefulness for the purpose. Even a rough test he thought would be of very great value.

With regard to glassware for illumination the endurance test specified by the B.E.S.A. had to be applied to the finished article and not simply to the material as glass. That was why the form of test specified was chosen. Glassware was not in actual practice submitted to a uniform temperature. The temperature distribution of glassware in actual use depended not only on the light source inside, but also on the design of the glass and its shape, and it was therefore thought that the best thing to do was to test the article when finished and ready to be placed under actual working conditions. He did not think that anyone was thoroughly satisfied with the particular test, but it was the best that could be proposed at the time. He would be grateful to Dr. English if he could suggest any improvements in it.

Mr. HAYDN T. HARRISON thanked the lecturer. He said that he had made a very special point of being present, because he had enjoyed a previous paper by Dr. English. He wished that the Navy had had the benefit of Dr. English's services, at any rate during the early stages of the war. There had been great trouble when a salvo was fired by one of the biggest battleships, as all the front glass of searchlights was broken, with the result that if there was a breeze or draught of any sort the lights would not burn. All sorts of remedies had been tried and everything that came along was tested. Very few varieties of glass stand the shock. Fortunately he had an inspiration as a result of the discovery that none of the mirrors was broken although subjected to practically the same conditions. These mirrors were better protected at the rear. It occurred to him that the best plan would be to remove the silver from the backs of the mirrors and put them in front of the searchlights until new glass could be supplied. This was done and the trouble ceased.

The formation of the glass was an extremely important factor. It was to be noted that when Dr. English was demonstrating with a short piece of sheet glass it returned to its normal condition when pressure was removed.

The greatest difficulties occurred when one had to deal with glasses of varying thicknesses, and from the early days of prismatic glass this had been a serious problem. He would like to congratulate Dr. English on the wonderful advances that had been made and also on the extraordinary ingenuity of the apparatus that he used in his research work.

Mr. F. W. HODKIN joined in congratulating the lecturer. A very complex subject had been presented in a very clear way. He thought that it might be inferred from what Dr. English had said that it was absolutely necessary to anneal perfectly every piece of glass. Some who purchased glass and found that it had not been treated in this respect, as the lecturer seemed to suggest that it should be, might be inclined to speak very severely to the manufacturer, but in many cases there was no justification for this view. Many manufacturers only annealed their glassware just sufficiently to prevent it from breaking under normal conditions of use. The presence of a little strain such as had been indicated by the lecturer was not necessarily sufficient to justify rejection.

Mr. SHELDON remarked that Dr. English had shown a slide that illustrated the temperature at which the coefficient of expansion began to rise rapidly. There was a very large difference between various glasses in that respect. Some had a low melting point and others were high heat-resisting. Dr. English had said that he had seen glass bottles used as hammers for driving nails into packing cases. He (Mr. Sheldon) had used an ordinary laboratory flask for the purpose.

With regard to resistance to atmospheric conditions or chemical action. A few years ago he was handling two different glasses, one of which, both theoretically and practically, had a much greater resistance to alkalies than the other. A gentleman who tested the glasses reported that the one with higher resistance was attacked while the surface of the other remained clear, thus reversing the position.

Mr. W. R. RAWLINGS remarked that the question of transparency had not been dealt with in the paper. A glass might be heat-resisting and have other good qualities, but if nearly all the light was boxed up within the glove it was not of much use from the point of view of illumination. Many housewives boiled glass to temper it, thinking they were adding to its life. He had always looked upon that practice as a playful idea, but it was a very common one. Was there really anything in it?

Dr. S. ENGLISH, in reply, thanked the speakers for the kind reception they had given his paper and for the comments and criticisms that had been made on it. He appreciated that Dr. Hampton had done a considerable amount of work on the question of the thermal endurance of glass. He knew of these investigations through committee work, and as the results of this work had not yet been published he preferred that Dr. Hampton should first of all mention it to the public himself. It had been known, of course, for a considerable time that the thickness of a piece of glass affected the temperature changes which that glass would withstand, but Dr. Hampton had been the first to reduce this more or less indefinite information to a mathematical expression.

In the work which was described in the paper the thickness of the glass was maintained constant by always using the same type of reflector, and therefore the results of tests showed up the changes which had

taken place in the thermal resistance of the glass iself, rather than of the article made from the glass.

Dr. HAMPTON, interposing, said the lecturer apparently thought he had missed a point. This was not the case at all. He was not overlooking the pressing properties, but there would be no difficulty in using, for making pressed articles, much harder glass and with a greater heat resistance than that shown.

Replying to this comment, Dr. English agreed he did not mean to suggest that the point had been missed. He fully realized that one could get glass which was much more heat-resisting than the 5B glass that had been mentioned, and that it could be pressed satisfactorily. As a matter of fact, the heat-resisting Bozal glass which was described was a glass of this type, but for ordinary illuminating ware a glass of this quality is not called for; moreover, in ordinary illuminating ware, appearance counted for a great deal, and it was exceedingly difficult to get a strong heat-resisting glass perfectly colourless, and the public would much rather have a colourless glass of the quality of 5B than a more heat-resisting glass showing an unpleasant colour.

With regard to the comparison between illuminating glassware and window glasses as regards heat resistance, it must be admitted that window glass was quite good from this point of view, but its composition was such that it would not press easily into prismatic form and give thin flanges and neck rings without splitting or crizzling. Moreover, one must remember that glassware of the quality demanded by illuminating engineers and the public in general is much better prepared in closed pot furnaces than in open tanks. For this reason, a glass which melts rather easier than ordinary sheet glass is required. As a matter of fact, the window glass is much more heat-resisting than most of the ordinary bottle glasses or domestic glassware now used. Once more, Dr. English wished to emphasize that the glass 5B could only be looked upon as semi heat-resisting, and should only be used as such.

Replying to the point concerning the durability of glass, it was interesting to hear that Dr. Hampton had come to the conclusion that 15 per cent. of soda was the limit of durability for soda lime glasses for use in tropical countries, but the glasses under consideration are not simple soda lime glasses. They contain appreciable amounts of boric oxide and alumina, under which circumstances the percentage of soda can be materially increased without passing the durability limit. As a matter of fact, the glass 5B, with 16.2 per cent. of soda, had been found in practice perfectly satisfactory from this point of view.

Replying to Mr. Wilson, Dr. English was glad to have his confirmation of the point made in the paper that breakages in domestic glassware were now much less frequent than they were in pre-war days. This may be due to better annealing, but the question of mechanical strength was of great importance. As pointed out in the paper, the mechanical strength of glass and its resistance to thermal shock are closely allied, and for this reason no data was given concerning this particular point. Nevertheless, it had not been overlooked.

Dr. English was much interested in the remarks made by Dr. Walsh concerning the navigation lenses and the conditions they had to withstand. Several years ago this particular problem was put up to the lecturer by a glass manufacturer who was in trouble owing to his navigation lenses not being able to withstand these strenuous conditions satisfactorily, but at the present time glasses are being manufactured which give no cause for complaint. The test which was suggested for these glasses, that is, a measurement of the density, may have been useful so long as only soda lime glasses were used, but the satisfactory glasses of the present day are much more complex than this, and therefore a density measurement is of no real value at the present time. Since the durability measurements which are described in the paper necessitate the breaking of the glassware in order to obtain greater speed in carrying out the tests, it is naturally not suitable for a number of purposes, but one committee on which the lecturer served had had this question under consideration for some time, and was on the point of issuing details of a durability test which does not necessitate the breaking of the glass, but it occupies five hours, and requires fairly delicate manipulation.

Dr. English appreciated that the tests specified by the B.E.S.A. for the thermal endurance of a lighting fitting was intended to test the fitting, and not the glass as glass. He was not surprised to hear that some people were dissatisfied with the particular test, but in view of the fact that the test had been devised by a well-informed committee, after quite a number of meetings, he did not feel competent to suggest an improvement on that test at a minute's notice.

Dr. English was interested in the details given by Mr. Haydn Harrison concerning the breaking of searchlight front glasses and the way in which this difficulty had been overcome. There was no doubt that the shape of the glass materially affected its resistance to fracture, either by mechanical blows, vibration or heat. For this reason, in a floodlighting unit for 1,500-watt lamps with a prismatic distributing glass front, a curved or bowed lens was being used. This was found to be very much more satisfactory than a flat plate.

Replying to the point raised by Mr. Hodkin, Dr. English said he was sorry if he had given the impression that it was always necessary to anneal a glass perfectly. This was not so, except in the case of optical glassware. For ordinary glass a certain amount of strain could be left in with no disadvantage, and in certain cases, for instance unbreakable tumblers and certain gauge glasses, strain was deliberately introduced.

Replying to Mr. Sheldon, Dr. English agreed that glasses have very different annealing temperatures. These are determined by the composition of the glasses, but whatever the annealing temperature the glass happened to be the range in which rapid expansion took place was always found to coincide with this annealing range. As a matter of fact, the determining of this range of rapid expansion was one method of determining the range of temperature in which a glass could be satisfactorily annealed.

Dr. English also agreed with Mr. Sheldon that the determining of the durability of the glass was one which required a certain amount of experience and care, since some glasses, which were very easily attacked, maintained a comparatively clear surface while others, which were attacked with only great difficulty, developed a kind of an opaque layer over their surface. To the uninitiated it would appear that these glasses with the opaque layer were more easily attacked than the others which maintained a clear surface, whereas, as a matter of fact, the reverse is often true.

Mr. Rawlings had asked about the transparency of glass. That was a subject that had been dealt with fully in the paper presented to the Society last year. Data was presented in that paper showing the transparency of clear glass, satin-finished, sand-blasted and opal glassware, so that Mr. Rawlings could obtain the information required by referring to that paper.

Referring to the boiling of glass with a view to improving its life, this was a practice which, as Mr. Rawlings said, appeared to be somewhat common; so far as he (Dr. English) could see there was no ground for expecting that such a process would improve the glass from the point of view of resistance to knocks, but, on the other hand, a treatment of this kind did tend to improve the apparent durability or resistance to weathering of glass.

The PRESIDENT, in winding up the proceedings, said that the discussion had been exceedingly interesting. The glass industry, almost more than any other, had developed since the war great open-mindedness and readiness to take advantage of the results of scientific research. One was glad to find that an effort was being made to bring British glassware up to the standard of the best in the world. Dr. English and the company with which he was associated were to be congratulated on what they had done.

He would move a hearty vote of thanks to Dr. English for his paper, and to the Holophane Company for their generous hospitality and their kindness in inviting the members to witness the display about to be given by Mr. Gillespie Williams.

Colour Lighting

By R. GILLESPIE WILLIAMS

(Abstract of a Lecture given in the Holophane Colour-Demonstration Theatre, at the Meeting of the Illuminating Engineering Society, on April 30th, 1929.)

THE scientific illumination of the cinema and theatre stage, and the employment of colour lighting in the auditorium as an element in the decoration of the cinema and the entertainment which it furnishes, were dealt with fully in a lecture given by Mr. R. Gillespie Williams, in the Holophane private theatre, following the discussion of Dr. English's paper.

It was important, when dealing with coloured light, Mr. Gillespie Williams contended, to differentiate between the results obtained by mixing two coloured lights and by combining two pigments of similar colours. For instance, if blue and yellow light were superimposed white light was obtained; but if blue and yellow pigments were mixed one obtained green.

Special attention was drawn to the need for care in superimposing coloured light on coloured objects; without some knowledge and experience of the subject results quite other than those desired might easily be obtained.

Installations should be planned by those who understood the science of colour, and who had considerable experience in its application. This science was only in its infancy, and hypothetical and inaccurate theories must be recognized as such, and ignored.

Coloured light had not been used to any great extent in the past, but an era was now commencing in which the science of colour and colour lighting was going to play an important part, and the cinema especially would take a leading rôle in their use and development.

The first demonstration was designed to show that a stage setting composed entirely of white material could be made to yield a galaxy of colour effects by means of general lighting alone. The scene took the form of Aladdin's Cave, and the stage properties were composed entirely of white cardboard and white canvas. In conjunction with music from a gramophone, the stage scene yielded a great variety of beautiful colour effects.

It was next shown that a pair of stage curtains could be so changed by coloured light as to place in the hands of enterprising showmen the means of having different curtains almost every week. Plain curtains with circular centre medallions were used for the demonstration, and it was shown that, firstly, the medallions might be changed in colour while the curtain itself remains unaltered, or alternatively that the curtains themselves might appear to be of quite different colours. In the first place the curtains were seen to be red, with black medallions. The medallions were then changed to green, blue and turquoise without affecting the colour of the curtains. The curtains themselves were then changed from red to light brown, dark brown, magenta, orange, crimson, and yellow, and it was shown that by half-and-half measures many different effects were obtained.

The value of colour lighting for musical interludes in the cinema and theatre was next demonstrated by means of a painted scene portraying camels and palm trees in a desert, with pyramids and an Eastern city in the background. In conjunction with suitable musical accompaniment, the scene passed through a gradual change from night to midday, and then through an Eastern sunset back to night. The dawn effects were particularly beautiful. It was also observed that when night was again shown the shadows of the camels and trees had disappeared.

The stage was next set with a drop scene painted to represent a ship at sea. By a change of lighting the sea scene vanished, and the canvas showed a Grecian picture with portions of a temple in the foreground.

The interior of the Holophane demonstration theatre is illuminated with special colour-lighting equipment, and the walls have been specially decorated so that by the manipulation of dimmer controls the colour scheme of the interior may be changed a number of times. These changes were demonstrated, and were of particular interest, as ordinary wall-papers are used on the walls, and these have not been touched or in any way altered. At one stage the centre panels appeared with a black background, the surrounding portions of walls appearing red, and the next moment the centre panels had a turquoise background while the walls were of a fawn colour.

A special dimmer control, in form resembling an aeroplane "joy-stick," was used to control the hall lighting, an interesting feature being that only one handle needs to be manipulated, different positions of this handle giving any desired combination of coloured lighting. It was shown that an unskilled operator could quickly master the more intricate colour combinations with this special controller, and, moreover, could quickly change from one colour combination to another.

Some very effective changes in colour were obtained from a lady's tea gown worn by one of the lecturer's lady assistants. The tea gown, which had a Chinese design, appeared to be black, green, blue, and turquoise, with corresponding changes in the colours of the design when viewed under different combinations of coloured light. The colour changes were particularly sharp and effective, and adequately demonstrated the lecturer's remarks with regard to the future of coloured light for stage costumes.

Perhaps one of the most interesting demonstrations was when a special demonstration lighting fitting was used to show the difference in colour hues between colour-sprayed lamps and scientific reflector equipment with colour screens. It was seen that large numbers of striking colour hues produced by a combination of two or more colours from the reflector equipment were not visible when the same colour combination was effected with sprayed lamps. The lecturer explained that while sprayed lamps offered a practical solution to many problems they were not so suitable for colour work where the primary consideration was the procuring of a large number of colour hues from the combination of two or more main colours. The lecturer particularly emphasized the optical nature of colour, and urged that more consideration should be given to such factors as contrast, intensity and hue.

The International Illumination Congress

(Held in the United States, 1928).

A meeting of the Illuminating Engineering Society was held in the lecture theatre of the Home Office Industrial Museum (Horseferry Road, Westminster, S.W.1) at 6-15 p.m. on Tuesday, May 14th, the PRESIDENT (Mr. C. C. Paterson) in the chair.

The minutes of the last meeting having been taken as read the name of the following applicant for membership was announced :—

Country Member:—

Bagh, A.....................Electrical Engineer, Vesterbrogade, 99, Copenhagen, V., Denmark.

The names of applicants presented at the last meeting were read again and these gentlemen were formally declared members of the Society.*

The PRESIDENT then called upon Mr. G. H. WILSON to read his paper reviewing the proceedings at the meetings of the International Commission on Illumination and the International Illumination Congress held in the United States last year. The paper proved to be of great interest, and a discussion ensued in which Dr. J. W. T. WALSH, Mr. R. WATSON, Mr. P. GOOD, Mr. J. M. WALDRAM, Mr. J. S. DOW and the PRESIDENT took part.

General appreciation was expressed of the admirable manner in which Mr. Wilson had discharged his task. The President and other speakers referred to the forthcoming International Illumination Congress to be held in this country in 1931, urging all members of the Society to do their utmost to render this congress an outstanding success.

* *The Illuminating Engineer*, June, 1929, p. 135.

Ultra-Violet Light in Technical Research

By LEONARD V. DODDS

THE production of the analytic quartz lamp is a noteworthy development in the application of ultra-violet light to commercial enterprises, and within a very short time it has been proved to be an extraordinarily efficient medium for analytical work.

The instrument contains a mercury vapour vacuum quartz lamp built into a box-like structure. As in all lamps of this type, the radiations are generated by passing a direct current of electricity through the vapour of molten mercury contained in a quartz generator, electrons in the form of ultra-violet energy being driven off similarly to X-rays. A converter in the burner, however, permits the use of alternating current which is of considerable practical value. To filter the ultra-violet rays and permit the observation of the fluorescences, a special glass filter is used which only transmits the wavelength between 4,400 A.U. and 2,800 A.U. This entirely supersedes the old type of filter made from a solution of various salts and dyes, such as the Wood filter in which copper-sulphate and a deep orange dye, nitrosodimethylaniline, in a container of uviol blue glass were used. Small curtains are provided for shutting out the light and complete darkness is not by any means essential, as the ultra-violet intensity of the quartz burner is sufficient to show even in broad daylight the characteristic fluorescence of the substance examined.

The apparatus has already multifarious uses and its field of application is constantly being enlarged. Without doubt the discovery of the phenomenon of fluorescence is one of the outstanding achievements of recent science. When rays of filtered ultra-violet light strike a substance capable of fluorescing they are changed into visible light of longer wavelength, and a curious glow is seen which varies in colour according to the substance examined. An extremely large number of substances will show a characteristic fluorescence, while American scientists have stated that every substance possesses this property, and the unknown can be determined by comparison with the known. The truth of this assertion has yet to be proved, but those substances possessing the power can be detected to an extraordinary degree of accuracy when using the analytic quartz lamp, and a well-known authority has stated that " we therefore have at our disposal a method of investigation which, in its precision, approaches the spectroscope."

By examination in dark ultra-violet light vegetable oil can immediately be distinguished from mineral oil and some mineral oils can be classified according to their origin. Casein fluoresces more than gelatine or any other protein and also more than cellulose; while of coloured materials, many colours which fluoresce can be distinguished from similarly coloured materials which do not fluoresce. A borax bead, even though it contains only a trace of oxide, is colourless, but distinctly fluorescent, while of quinine, aesculin and uranin colours belong to to the bodies which fluoresce to a remarkable degree, so that even very small quantities of these substances can be detected in ultra-violet light. To illustrate the marvellous degree of accuracy obtained, one part of aesculin can, under favourable circumstances, be detected in a water solution of one part in 10,000 millions by its distinct fluorescence.

In the testing of drugs filtered ultra-violet light is a very efficient medium, and the method has been developed with considerable success. Herren P. W. Danckworte and E. Pfau, attached to the Chemical Institute of the School of Zoology at Hanover, have investigated the most important pharmaceutical alkaloids and a number of drugs to obtain data as to their constitution from their fluorescences, and one result of this work is that the capillary-analytical method of tests has been established on an entirely new basis.

The method of capillary analysis has often been recommended for the investigation of drugs, but has not been developed to any extent. When the capillary strips are examined in ultra-violet light, however, the reason for this becomes apparent, and the method elaborated by Herr Pfau is now recognized as invaluable. Writing in the *Archiv der Pharmazie und Berichte der Deutschen Pharmazeutischen Gesellschaft*, Herr Pfau describes the method. When an ordinary capillary specimen from an extract of opium is examined in daylight, an upper brown zone due to colouring matters is seen, but colouring matters are not the typical substances we look for in drugs. A drug may display the correct appearance and yet contain too little alkaloid; or an appearance differing from the standard strips, such as we have in the laboratory, may be obtained, and yet the alkaloidal content may be correct. If the strips are now placed under the lamp, the light blue zone of the morphine can be distinctly seen over the colouring matter zone. Therefore it may be stated generally that the capillary strips, if observed under the quartz lamp, firstly reveal zones which cannot be seen by daylight, but which show the substances which are of therapeutic value; and secondly that colour zones undergo a change of colour and intensity. Investigation of the capillary strips is not limited to drugs containing alkaloids, and, as well as to other drugs, the method may also be applied to pure colloid solutions.

The microscope may also be used in conjunction with the analytic quartz lamp, and this is a method which botanists and chemists are now demonstrating successfully. The lamp must be tilted so that the rays are caught by the reflecting mirror and it is inadvisable to use slides made of quartz owing to the consequent strain upon the eyesight. Ordinary slides made of glass allow the luminosity to be seen sufficiently well, and the adaptability of the instrument, together with the power of the rays, opens up a vast field for research, the great scope of which has not yet been investigated.

Willemite is a mineral of comparatively rare occurrence, but it has long been mined in New Jersey as an important ore of zinc ($Zn_2 Si O_4$ containing Zn. 58.6 per cent.). As a distinct mineral species willemite was first recognized in New Jersey in 1822, but apparently it had been mined for some years previously, being known as " silicious oxide of zinc." Under ultra-violet light a piece of New Jersey willemite glows with a wonderful brilliancy, the colour being of uranium green. The massive radiating willemite from near Lusaka, in Rhodesia, showed a dark green fluorescence, while a specimen from another locality showed bright yellow, and yet others did not fluoresce at all. Dr. L. J. Spencer, F.R.S., Keeper of Minerals in the British Museum, deduces that in many instances this mineral can be classified according to its origin, but states that it is evident that fluorescence in ultra-violet rays is not a constant and essential character of a mineral species, being shown by some specimens and not by others evidently dependent on the presence of some admixed impurity in the material. In this connection W. S. Andrews has shown that artificially prepared willemite is only active when it contains some manganese, the shade of the green fluorescence depending on the amount of manganese present.

A less technical development is one which is now being used extensively by students engaged in historical research and has resulted in a very large amount of material being available which it has hitherto been impossible to use. In olden days, when parchment was used for writing upon, it was not thrown away when time had rendered the document worthless owing to labour and the expense of producing the material; instead it was carefully cleaned by mechanical and chemical means, and then used a second and even a third time. In many cases the original script would be of far greater historical value if it were available, and now the use of filtered ultra-violet light has not only made this possible, but, consequent upon a method evolved by Professor G. R. Kogel, of Vienna, a photograph can be obtained of the original writing, which may have been erased thousands of years ago. This is possible because the old tints and dyes left in the parchment after the cleaning process fluoresce distinctly from the latter tints and from the parchment itself. In the photograph the superimposed text appears as if written in outline type,

that is, white lettering with a narrow black edge, and underneath this can be seen quite clearly the dark grey lettering of the original script. Certain imperfections due to the varied action of the cleansing process are to be expected, but it is seldom that any difficulties occur in deciphering.

Ultra-violet light is an extremely powerful sterilizing agent, and in many commercial enterprises this property is being used extensively. In the preparation of food-stuffs exposure to the rays increases the vitamin content of the product, and this, combined with the sterilization, is now being generally practised. Butter oils, cod-liver oil, and others containing anti-rachtic vitamins, emit a yellow fluorescence under filtered ultra-violet light, while inactive oils, such as pea-nut oil and olive oil, show white. When the latter have been exposed to strong ultra-violet light they fluoresce yellow, the colour deepening in proportion to the intensity of the rays, Butter itself is treated in one factory by being spread out on an endless band passing before a mercury-vapour lamp. Though there is a slight chemical change there is no apparent difference either in taste or colour.

Quite recently means have been devised for the mass production of irradiated dried milk. This is a product desiccated by the revolving double-cylinder process, and it is exposed to the rays of a mercury-vapour lamp in a manner by which practically the entire surface of any given particle of milk solids can remain within the activating influence of the rays for an estimated period of about one minute. There is no evidence of a disagreeable flavour or odour commonly found in milk products exposed to ultra-violet irradiation for a long time, and the usual keeping qualities of the product are apparently unimpaired. Many similar applications are now in process of development, and the canned meat, fish and fruit industries will very probably adopt the method when certain technical difficulties have been overcome.

A special apparatus has been evolved for the sterilization of fluids in view of the widespread use which is being made of the method, and similar apparatus is used for the general purpose of accelerating chemical reactions. The fluid is placed into a tube encased round the illuminating tube, and as the distance at the most is 15 mm. from the light arc, all the fluid obtains immediate radiation. At such close range exposure of fractions of seconds is sufficient to kill off all organisms. A burner of this kind can effectively sterilize 650 gallons of infected water per hour, and though for the water supply of towns such a method would be too expensive, yet in hospitals, pharmacies and many industrial processes it is being used successfully. In America a manufacturer of mineral waters has a battery of lamps which is capable of dealing with 20,000 gallons of water per hour. To produce complete sterilization by this method the water must be absolutely clear, for, with a turbid fluid, even though the turbidity is not noticeable to the eye, the power of the ultra-violet rays is neutralized by a layer of water of 3–5 mm., so that the whole thickness of 10 mm. contained in the encasing tube would not be penetrated. Consequently filtration must be of the very best, and both felt and sand filters are usually employed.

It is incorrect to assume from researches such as these that artificially generated ultra-violet light is necessarily stronger than those rays from the sun. Actually the solar ultra-violet energy is greater than that of the ordinary mercury arc, though the biologic effects are less intense. This has recently been demonstrated to the Academy of Sciences in Paris by M. Jean Lecarme. The method for measuring the intensity was dependent on the decomposition of oxalic acid in the presence of uranyl and a catalyst. Measurements were carried out at various altitudes, the highest being Mont Blanc Observatory (4,350 metres), and it was noted during the experiments that whilst the solar radiations produced a rapid decomposition of the oxalic acid, the effects due to the light of the mercury-vapour arc were scarcely sensible. In agriculture, horticulture and stock-keeping the value of ultra-violet radiations has now been recognized, and it is in the use of natural light aided by a glass permeable to the rays that the greatest success has been gained. In consequence of M. Lecarme's researches it is demonstrated quite clearly that for work of this kind the sun is superior to the most efficient lamp.

The application of ultra-violet light to industry and to agriculture is an outstanding scientific achievement of great economic importance, and the further development of technical research into the many still-unknown properties of ultra-violet light may produce results of even greater value.

The Possibility of Signalling by Means of Ultra-Violet Rays

During the great war, as is well known, various methods of "secret signalling" by means of ultra-violet rays were investigated. The advantage of being able to signal by a Morse system, without the flashes being perceptible to the enemy, is obvious. The method involves essentially the use of a source of light rich in ultra-violet and capable of furnishing a highly concentrated beam, in conjunction with a screen of special glass practically opaque to visible light but allowing ultra-violet rays to pass.

The problem has recently been examined anew by Monsieur Y. Rocard, in a contribution to the *Revue Optique* (Jaunary, 1929, pp. 9 to 15). The author commences by reviewing the various sources of ultra-violet light available, of which only the arc light and the quartz tube mercury-vapour lamp are regarded as likely to prove of practical value. The mercury-vapour lamp with quartz tube is admittedly capable of furnishing intense ultra-violet energy of small wavelength, and it has therefore many important practical applications. Nevertheless the author considers that it is, for signalling purposes, greatly inferior to the electric carbon arc; for processes of secret signalling involve the production of a concentrated beam and the focussing of an image of the source, either on a fluorescent plate or a photo-electric cell. It is inferred from experiments that for this purpose an arc between carbon electrodes is at least 20 times as efficient as the quartz mercury lamp, and that the efficiency of the Sperry arc with cooled electrodes is probably 60 times as great.

An attempt is next made to determine the efficiency of the process of transmission and reception by means of a fluorescent screen. For this purpose the luminous image of the arc and the fluorescent image produced by the ultra-violet light were assembled in juxtaposition. The brightness of the latter was only about 1/700 of the former and even this figure is only attained with the best type of fluorescent screens. With less sensitive types a brightness only 1/20 of that recorded above was obtained. A calculation of the possible range of signalling by such methods was made and the results are assembled in tabular form. The range attained with Beck and Sperry searchlights was higher than might be expected, varying from 4.5 to 70 kilometres according to the degree of transparency of the atmosphere. On the whole the results attained by reception on a fluorescent plate seem superior to those recorded with a photo-electric cell, although, theoretically, the efficiency of the latter process should be the greater.

The Illumination of Large Open Areas

A paper by M. Massing on the above subject was recently presented before the Société Francaise des Electriciens. Experience from the United States was quoted to show the advantages of floodlighting in facilitating the moving of railway wagons and in preventing accidents. In general, projectors should be placed at a height of not less than 25 metres with a view to avoiding glare and troublesome shadows. The illumination recommended was 1-5 lux for railway tracks, 10-30 lux for docks, quays, depôts, etc., and 20-80 lux for large areas given up to games and sports.

POPULAR & TRADE SECTION

COMPRISING

**Installation Topics—Hygiene and Safety—
Data for Contractors—Hints to Consumers**

(The matter in this section does not form part of the official Transactions of the Illuminating Engineering Society; and is based on outside contributions.)

Electric Light in the Garage

By J. L. H. COOPER

(E.L.M.A. Lighting Service Bureau.)

THE increase in the number of both public and private garages and service stations throughout the country is part of the remarkable expansion of the motor car industry, and experience has shown that the lighting conditions are far from satisfactory, and as such do not do justice to this progressive industry.

The buildings vary from the modern establishment, designed for the particular purpose of selling and maintaining cars, to the blacksmith's shop, which has been modified to meet the requirements of modern vehicular transport.

The importance of correct illumination in garages cannot be over-emphasized. Where correctly designed lighting of the proper intensity is installed, more accurate work is accomplished, fewer mistakes occur and less material is spoiled; in other words, lighting is one of the most important factors in securing the highest possible efficiency.

In addition, working conditions are improved since the accident risk is reduced, and the staff remains alert and more attentive to its work.

The science of lighting has advanced rapidly during recent years, so that the provision of a lighting system for any specific class of work is no longer a difficult matter, and the installation can be designed to produce specified results, thus ensuring that full benefit is obtained for the capital outlay involved.

Public Garage.—There is considerable room for improvement in lighting the main floor of the average public garage. The proprietor, in the majority of instances, thinks it is quite sufficient to install a few bare lamps of high wattage, or a number of smaller gas-filled lamps in obsolete enamelled iron shades; the blinding glare which results from this crude method of lighting makes the placing of a car in position a hazardous operation, even though an extremely low speed is employed. In addition, scratched mudguards and other damages result from the crowded condition of most garages and the heavy shadows which prevail.

It is obvious, therefore, that the storing space in the garage should be uniformly illuminated to an intensity of five foot-candles by the employment of modern equipment.

In all parts of the garage, the ceiling and upper portion of the walls should preferably be light in colour, as this materially assists in the light distribution and also in the elimination of heavy shadows.

The Wash Down.—Special attention should be given to the lighting of that portion of the main garage where cars are washed, since it is obvious that a car can be cleaned better and more quickly if sufficient light is provided to enable the cleaner to see his work clearly. It is difficult to produce a high degree of illumination on the vertical sides of cars from an overhead system of lighting designed to produce uniform horizontal illumination, but this difficulty can be overcome by using pearl or opal lamps in industrial angle reflectors suitably located and spaced.

FIG. 1.—A Well-lighted Garage.

Machine and General Repair Shops.—The repair job is a very intimate point of contact between the motor industry and the general motoring public. A reasonable charge on such a job produces a satisfied customer, secures his future business, and as a considerable portion of this charge is based upon the time expended, the influence of correct lighting is of paramount importance.

In the machine and repair shops, a general uniform illumination is recommended and the intensity should not be less than 10 foot-candles. The lighting units may be either the dispersive or concentrating type of reflector, correctly installed, and equipped with the proper size of lamp.

Local Lighting.—Although general uniform illumination will meet the requirements of the average workshop, there are occasions when a high intensity of lighting is necessary, such as on the bench or on the machine. This additional lighting should be obtained from adjustable brackets which can be clamped to the bench or machines. The avoidance of glare, which frequently occurs with local lighting units, may be attained by using a concentrating reflector and an obscured type of lamp.

The provision of switch-plug points is essential in every repair shop, particularly in the inspection pits, for the use of hand-lamps and the last-named should always be of the Home Office pattern and provided with an obscured type of lamp and tough rubber flexible cable to withstand rough usage.

Showroom.—Generally speaking motor car showrooms are located in districts where rental charges are high, and every advantage of the situation must be utilized in order that the returns may justify the heavy overhead expenses. During recent years the value of light in showrooms has been more and more recognized as a sales builder, and a well-lighted showroom will always compel attention and is a stimulus for a greater sales turnover.

The use of coloured light is also worth consideration for showroom displays, and as appearance has much to do with the popularity of the car the time and energy expended in making it attractive will be amply rewarded.

It is desirable with the present-day tendency towards bright colours in coachwork that some consideration should be given to the type of illumination which brings out these colours in their true value, and this can be accomplished by the use of daylight blue lamps. It is not suggested that this method of lighting should be employed for general illumination purposes, but rather for the special purpose of assisting the salesman in displaying his goods.

Another interesting feature of this illumination by artificial daylight is that it makes it possible for the salesman to show the prospective customer how the car would appear in the daytime, thus facilitating sales and saving time.

Window and Interior Lighting.—The actual size of the window space which is usually set apart for the display of accessories varies considerably in depth. If the window is five feet or over in depth, the lighting can be readily accomplished by installing 100-watt pearl or opal lamps in reflectors placed at the top of the window and spaced one foot apart. If flame-tinted lamps are used in every third reflector, the resultant illumination will be much more mellow and more pleasing in tone.

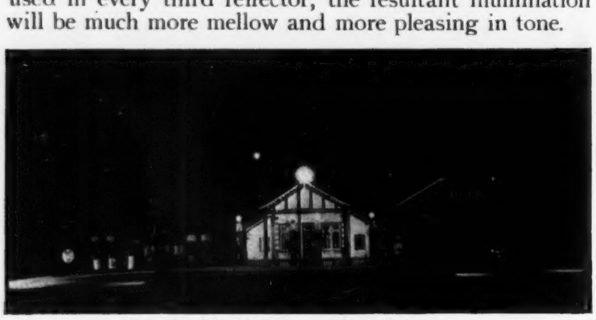


FIG. 2.—Floodlighting a Wayside Garage.

The lighting of the showroom interior becomes one of general illumination of a uniform character, and for the ordinary showroom the totally enclosed type of unit with a one-piece diffusing globe will be found the most suitable. The mounting height and spacing of these units will be governed by the ceiling height, and if this is, say, 14 feet high, 200-watt gasfilled lamps in totally enclosing units mounted 12 feet from the floor, spaced 10 feet apart, will provide adequate illumination in the interior.

Here again light-coloured walls and ceiling will materially assist the illumination, apart from enhancing the appearance of the showroom, which should, of course, be made as attractive as possible.

Exterior Lighting.—The external appearance of a garage will very often indicate to the motorist the kind of service he will obtain and in order to create a good impression it is essential that the proprietor should aim at making the exterior of his building appear attractive and business like.

Floodlighting the face of the main building is well worth considering, and makes the building stand out, creating an impression of an up-to-date service garage. The placing of the units will depend on the type and location of the building, and each case must be treated on its merits. The floodlights may be placed on the building itself, concealed from view at the sides, mounted on ornamental standards or housed in the base of floral boxes. When installing floodlights, care should be taken not to obstruct the view of motorists when approaching, entering or leaving the garage premises.

Private Garage.—The lighting generally provided in the private garage is usually of a crude form, consisting of either a drop pendant or a bare lamp. The cost of providing efficient reflectors and lamps will be more than repaid by the saving in clothes, time on minor repairs or adjustments, and the all-round general convenience provided when garaging the car.

The portion of the garage to be well lighted is that occupied by the forward end of the car, and if there is sufficient headroom of, say, 10 to 11 ft., a good intensity will be provided by a 100-watt obscured type of lamp, in a dispersive reflector, mounted 10 feet from the floor and located five feet from the forward end of the garage.

If the ceiling is particularly low a ceiling fitting of the bulk-head type will be found most suitable.

If the garage is provided with a door at each end, a two-way switching arrangement with a switch at each entrance will also add considerably to the convenience.

A switch plug is essential in every private garage and this should be located on one of the walls in a central position for use with a hand-lamp, which should be of the Home Office pattern and provided with an obscured type of lamp to eliminate glare.

Experience has shown that a light placed well above the main entrance to the garage is extremely useful for the lighting of the carriage drive and enables the driver to reverse his car with safety and minimum delay. A bracket with a watertight glass fitting equipped with a 100-watt obscured type of lamp will provide good illumination on the carriage way and surroundings for the average private garage approach.

In conclusion, it may be emphasized that good lighting plays a most important part in the garage, first as a means of attracting attention, and secondly as an essential to quick and efficient service. Instances could be quoted of wayside garages which have modernized their lighting with most favourable results, adding both to their regular clientele and to the casual business coming their way.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Some Further Notes on Lighting Exhibits at the Leipzig Spring Fair, 1929

By A SPECIAL CORRESPONDENT

IT might almost be said that although this wonderful fair, with more than 10,000 exhibitors, visited by over 200,000 trade buyers, embraces the best of products gathered from Germany and twenty-four other countries, including Great Britain, North America, India and Japan there is no effective display of "illuminating devices"—and this in spite of the fact that a whole section is classified as being devoted to illumination fittings. The six sample rooms in which this section, with its 250 exhibitors, is housed did not contain very much of interest to the illuminating engineer from a technical point of view. A magnificent display of living-room fittings was to be seen, constructed of metal, wood and glass with shade of equal diversity, but this section obviously caters exclusively for the older styles of decoration, and there were few genuine novelties to record. It was pleasing to observe, however, a desire to screen the filaments of the electric lamps from direct view, either by suitably shaped glassware or by veilings drawn across the under parts of silk shades. A modern tendency was evident in isolated instances; electroliers with vertical rod-like, milk glass lamps, pleasing to look at and easy to maintain clean and efficient, were here and there; the upper termination of the fittings, which on the Continent are usually covered by a cloth wrapping, is giving place to movable covers, permitting both easy connection to the supply wires and a neat finish by a metal spinning sliding up against the ceiling, while glassware was almost universally of good shape and material. The "Luroma" extensible down rod fitting is a happy departure from either chain or flexible conductor, applied with or without counterbalance weights, as it presents the same appearance whether the body of the fitting is raised or lowered, while movement is easy and without noise or jar.

In the building devoted exclusively to electrical engineering products and applications, the lighting fittings on view seem to have almost all reached a normal pattern, and to produce the kinds of light distribution which may now be considered as world standard, difference being in details only observable on close inspection. The desirable tendency to construct fittings of the simplest possible form embodying a minimum of metal while securing maximum ease of cleaning was well in evidence. The plain outlines adopted correspond to the prevalent style of the national architecture, as well as to the design of the furniture now being constructed, and while possessing an attractive simplicity may be described as expressionless. The desire to secure maximum efficiency and absence of glare was universal, but few examples of modernistic French designs of fittings were visible.

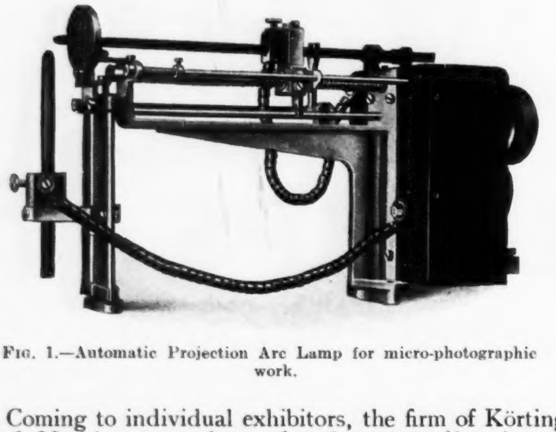

FIG. 1.—Automatic Projection Arc Lamp for micro-photographic work.

Coming to individual exhibitors, the firm of Körting and Mathiesen stood out for the great diversity of illuminants and of housings or lanterns appropriate to the light sources. They hold that the arc lamp is far from dead, and therefore exhibited their "Dia" long-burning flame arc lamp in such a way that its regularity of feed could be observed. These lamps were also seen erected on high masts effectively illuminating many of the open spaces of the city. Photo-process and cinema film production arc lamps were also seen, as well as a new design of fully automatic projection arc lamp, shown in Fig. 1. This lamp is intended for both lecture lantern and for micro-photographic work.

A great variety of carefully designed lanterns for incandescent lamps was shown, particular attention having been paid to street, factory and office lighting, as well as to the requirements of the working departments of residences, for which a new range of simple fitting suitable for kitchens, bathrooms, passages, cellars, etc., were shown.

Two patterns of table standards were seen, both with joints enabling the reflector to project its concentrated beam where desired. A typical table lamp is shown in Fig. 2.

FIG. 2.—Ordinary Table Standard.

The smaller pattern, intended for bedside use, is illustrated in Fig. 3, and, it will be seen, has a press switch conveniently placed on the base, which is, moreover, so constructed that the fitting may be hung on the wall and serve as a bracket light. The reflector may be brought close down to the pedestal below so that only diffused light is seen.

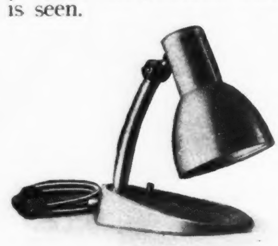

FIG. 3.—A smaller pattern designed to serve as a night light.

Examples of the operation of such units in practice are shown in Figs. 4 and 5.

The firm of Siemens-Schuckert, which had the most important general exhibit of electrical appliances in the fair, devoted a considerable portion of it to illumination devices, and took the opportunity of introducing a system of interchangeable glass parts, applicable to the same metal structure, intended to permit different lighting effects or distribution to be obtained without replacing the fitting. The mirror-back shop window-reflectors shown by this firm were claimed to be free of all risk of stripping, no matter how hot they became, as the silvering was overplated by a heat-spreading copper coating, which was then covered with a sprayed-on layer of aluminium. An interesting demonstration of the

value of partially corrected incandescent lamp illumination given on this stand clearly showed the value of this light in the detection of faults in textile goods.

FIG. 4.—Showing the use of the night light on the dressing table.

The Schaco fittings of the Schanzenbach Company, which has hitherto specialized in the construction of fittings suitable for chemical and other industries where abnormal and moist conditions are prevalent, were notable for the small quantity of metal employed and the large screw threads moulded on both the collars of the globes and the porcelain receptacles into which they go. By this arrangement and the use of a rubber gasket waterproof fittings of a practical nature were assembled. The breakages, in spite of the use of screw threads exceeding three inches in diameter, are said to be negligible. On the stand were also porcelain-based fittings for use in kitchens, bathrooms, and similar places, with encaustic enamel finish in brilliant and artistic colours, making a pleasing departure from the usual plain white finish.

The firm of Markus M. Bach showed several novelties in lighting devices, among which were the " Diskret " bedside lamp, a convenient device which is intended for hospital or invalid use. This fitting consists of a cylindrical standard with a metal wall so cut as to leave a free aperture, which is covered, as desired, either by a

FIG. 5.—A similar unit brought close to the diffusing base so as to furnish subdued illumination.

milk-glass or green-glass portion of an internal cylinder rotated by a milled head. Among other specialities exhibited by this firm were adjustable pendant and standard lamps, with shades giving semi-corrected light for use in medical and dental work, as well as specially tinted projection lanterns for use in butchers' shops and bacon dealers' stores.

The Bottlight Moskito lamps, shown in Fig. 6, will serve for ordinary purposes of illumination, but are also intended to solve a difficulty that arises where outdoor life after dark is more prevalent than in this humid climate. The fittings, made entirely of glass, in two sections coupled together by means of a bayonet joint, are easily separated, and into the lower one a suitable solution with an odour attractive to flying insects is poured. It will be noted that there is an aperture in this globe, and it is claimed the brighter light projected through this acts as an additional guide to the insects. The distance from the lamp bulb to the aperture being adjustable, the clearance in the hole can be made to suit desired conditions.

The department of hygiene contained many forms of lamps for therapeutical purposes, but that exhibited by the firm of Stock & Urban was perhaps one of the most practical, as in it both the parabolic mirror and the handle are insulated, while it is so constructed that the light filters can be varied in order to secure what are somewhat vaguely called blue, red, or white health-giving radiations.

Osram lamps with Vitalux glass bulbs were also prevalent in this department, shown adapted to convenient reflectors and standards so arranged that the human body, in any position, might be subjected to radiation.

Although no striking novelties were shown at this fair, it was interesting to note that glare-free fittings producing more or less standardized illumination curves have

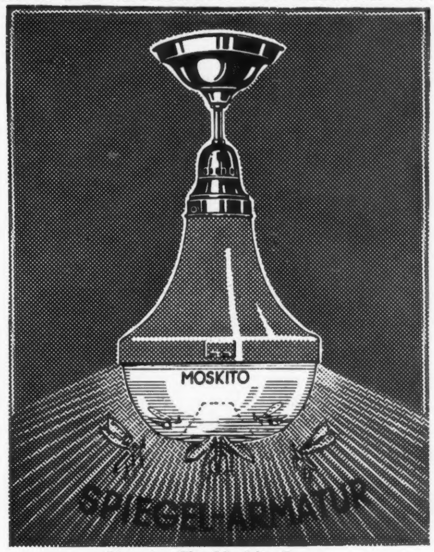

FIG. 6.—The Moskito Lamp.

become universally recognized as correct for all places except where purely ornamental designs are desired and efficiency and maintenance cost only play a minor rôle.

The Electrical Association for Women

VISIT TO NORTH-EAST COAST EXHIBITION.

The Electrical Association of Women, with characteristic enterprise, is arranging a visit of their members to the North-East Coast Exhibition in Newcastle-upon-Tyne during July 10th to 12th.

Mrs. Wilfred Ashley (President) and other leading members will welcome visitors on July 11th, when a pleasing feature will be the delivery of short addresses by ladies from Germany, Holland and the United States. A civic reception and dance has been arranged for the evening.

On the subsequent day the annual general meeting will be held at the Exhibition, followed by visits to Lemington Glass Works and other places of interest.

Further particulars may be obtained from the director of the E.A.W., Miss C. Haslett, 46, Kensington Court, London, W.8.

Personal Note

Lt.-Commander Haydn T. Harrison, R.N.V.R., M.I.E.E., informs us that his telephone number at 14, Victoria Street, Westminster, has been changed to Victoria 2943.

Commander Harrison is now very much occupied with research and testing work in the Benjamin Research Laboratory, Telephone No. Tottenham 3600, where he will be pleased to receive any communications should he not be at his office.

Gas at Three Large Exhibitions

(Communicated)

A COMMON feature of the British Industries Fair, held at the White City, London, and at Castle Bromwich, Birmingham, a short time ago, and of the Ideal Home Exhibition, at Olympia recently, was the extensive use of gas for numerous purposes—lighting, cooking, heating, water-heating, destruction of refuse and refrigeration of food.

British Industries Fair, Birmingham.—At the Castle Bromwich section of the Fair, the demand for gas was extensive. In the eight large kitchens, well over 200 pieces of gas apparatus were installed, and high-pressure gas lamps of well over a quarter of a million candle-power were used for lighting a part of the building.

The administrative and other offices of the Fair were heated by 50 gas fires, and a further 60 heating appliances were used for making the dining rooms, snack bars, and conference hall warm and comfortable.

The " Gas Section " of the Fair was an exceptionally large and fully representative one, consisting of over 60 exhibitors.

The exhibit of the British Commercial Gas Association consisted of a " Sunshine City " display, which demonstrated the great part which gas plays in relation to public health and hygiene. In past displays a strong anti-smoke appeal formed the predominant feature. This year the more positive aspect was emphasized: a beautiful colour scheme, with illuminated background, suggesting the ideal smokeless city, which will result from the more general use of gas.

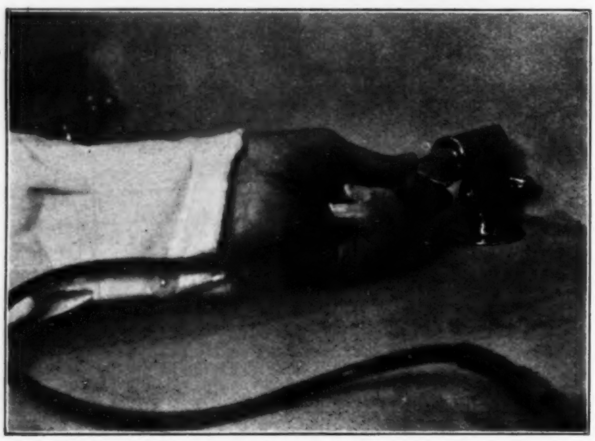

FIG. 1.—*A new Bayonet Attachment for the flexible tube of small gas appliances and standard lamps. The " bayonet " fits and locks (by a simple turn) into the socket which carries the gas tap. With this fitting the appliance can be easily and safely connected or disconnected in a couple of seconds.*

Some of the great public services, made possible by the scientific treatment of coal in the gas works, were indicated and illustrated in a pictorial as well as a practical manner. The exhibit made a strong appeal to municipal authorities, as well as to all interested in public health.

Over five miles of gas piping and 100 meters had to be provided to meet the needs of the exhibition authorities and the exhibitors, who were, at times, using gas at the rate of 30,000 cubic feet per hour.

British Industries Fair, London.—At the White City, where over 1,300 exhibitors showed their goods along stand frontages measuring eight miles, a thousand gas fires and radiators, for which no less than ten miles of piping had to be provided, were used for heating purposes. For the fourteen restaurants and buffets, the former capable of seating no less than 2,000 diners at one time, large kitchens were provided to cope with the wholesale demand for meals, and these kitchens were equipped throughout with the latest gas cooking and water-heating appliances.

During the busiest times of the day no less than 50,000 cubic feet of gas per hour was used.

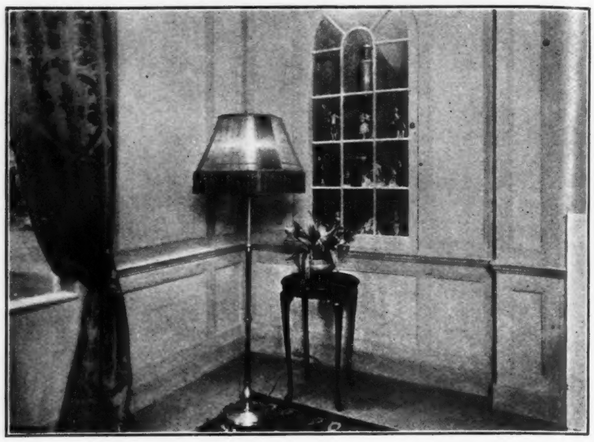

FIG. 2.—*A Corner of the Drawing Room in the London Gas Companies' Exhibit at the Ideal Home Exhibition, showing a China Cupboard lighted by concealed gas burners and a gas standard lamp with flexible tube bayonet connection of the kind shown in Fig. 1.*

Ideal Home Exhibition.—At the Ideal Home Exhibition, Olympia, the joint exhibit of the London Gas Companies was a centre of attraction, especially to women.

The drawing room, designed by one of the leading architects of the day, was essentially modern. The gas fire and the treatment of the fireplace were outstanding features. The lighting fittings showed how beautiful modern gas lighting can be. The burners were all turned on and off by means of distance switches.

The modern kitchen and the kitchen equipment were examined carefully by women and women journalists in order to gain an idea of the latest fashions in kitchen design and equipment. The model kitchen had the popular raised cooker, with a glass hood over it, and a new type of thermal storage heater which, with a maximum consumption of 10 cubit feet of gas, will heat water for domestic purposes to a temperature of 160° Fahr., and, when the storage tank is full of hot water, will maintain 20 gallons at the desired temperature with a consumption of only $1\frac{1}{4}$ cubic feet per hour. In another section of the kitchen there was a gas-operated refrigerator, noiseless and without moving parts. The gas-heated clothes-drying and airing cabinet (which has been on the market for some little time) was shown in an improved finish of shining white enamel.

In a special hall set apart for the display of different models of gas cookers it was noted that every appliance, whether large or small, was finished in enamel, which is evidently meeting the full approval of the modern housewife.

FIG. 3.—*A Gas Lighting Pendant with semi-opaque bowl painted in attractive colours.*

Fig. 4.—The Drawing Room of the London Gas Companies' Exhibit at the Ideal Home Exhibition was designed by one of the leading architects of the day. It was heated by a beautiful gas fire and lighted by gas standard and table lamps, concealed gas burners in China cupboard, and a lustre fitting fixed in the centre of the ceiling.

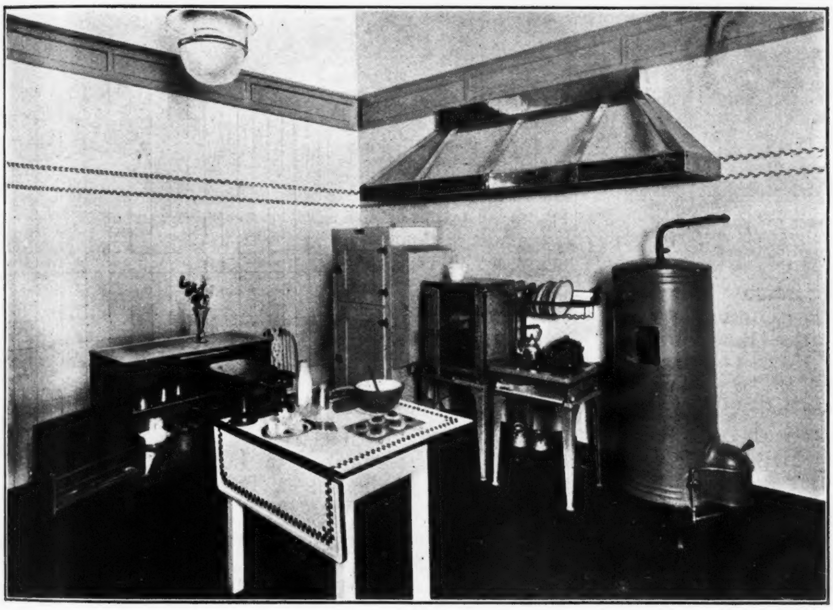

Fig. 5.—The Model All-Gas Kitchen at the Ideal Home Exhibition, showing enamelled raised gas cooker, gas water-heater, gas-operated refrigerator and semi-indirect gas lighting pendant. During the run of the Exhibition practical demonstrations of cookery in this kitchen attracted large crowds.

Fig. 6.—A Corner of the section of the Gas Companies' Exhibit in which the latest designs in all-enamel gas cookers were exhibited. The tiled recess is illuminated by a concealed gas burner fixed in the side of the recess. The room was lighted generally by gas burners with lustres of attractive design.

In the bathroom, lined with vitrolite, was a geyser fixed in a niche formed of that material. The most novel feature there, however, was an ingenious and inexpensive little gas heater for fixing in the lower section of an ordinary linen cupboard. To ensure ventilation of the cupboard one or two small holes have to be drilled at the top and bottom of the cupboard. The fixing of the heater is an easy matter, and by lighting the little gas burner an ordinary cupboard is thus turned into a really efficient airing cupboard, in which sheets

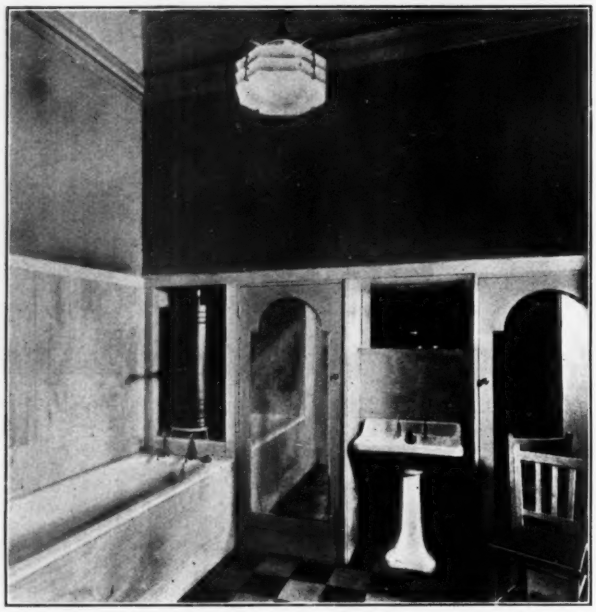

Fig. 7.—*A Model All-Gas Bathroom, showing geyser and gas lighting pendant of modern design. The cupboards are provided with small and inexpensive gas-fired heaters for airing linen.*

and blankets as well as smaller articles may be made absolutely safe for use, and the negatives and prints of the amateur photographer may be dried quickly and satisfactorily. The little heater costs from 15s. to 27s. in various attractive finishes.

The hot-water section contained the newest gas and coke water-heaters, some of the latter with open fires. Even the coke boilers were finished in enamel, and were consequently much improved in appearance.

The beauty of the gas fires in the gas fire section of the exhibit indicated clearly the close co-operation now existing between the gas industry and the architectural profession.

The "mere man" had not been forgotten in this exhibit. For the amateur carpenter and the wireless fan there were gas-heated glue-pots and gas-heated soldering irons. These and a number of other "portable" appliances, such as boiling rings, table lamps and gas irons, were connected by flexible tube to the gas supply by a simple "bayonet" fitting which has only to be pushed into a socket to ensure a supply of gas.

The houses which formed the village of "Welcome In" showed a remarkable diversity of styles. In all of them, however, a definite attempt had been made to reduce the drudgery of housework to a minimum. Every one of these houses—even the week-end cottage—contained some sort of gas appliance—recognition on the part of architects and those responsible for the equipment of homes of one of the housewife's most important needs. They have realized that she must have an economical fuel for lighting, for heating the house, for heating water and for cooking, which is easily controlled and entails no dirt or heavy labour.

Fig. 8.—*A Model Study, planned by Sir William Arbuthnot Lane, C.B., M.S., F.R.C.S., "to suggest peace, comfort and brightness with nothing to distract attention . . . The heating of the room is so arranged that, while the gas fire does not project into the room and is inconspicuous, it supplies just as much heat as is desired, and furnishes the most efficient form of ventilation." The room was constructed, furnished and shown at the Ideal Home Exhibition by Messrs. Waring & Gillow, Ltd.*

E.L.M.A. Lighting Service Bureau

(Nineteenth Illumination Design Course).

The programme of the 19th Illumination Design Course of the E.L.M.A. Lighting Service Bureau is now available in a well-arranged booklet which contains illustrations of the architectural lighting room and others of the special exhibits at 15, Savoy Street.

The series of lectures, which will occupy the period from June 10th to June 13th, is again a varied and comprehensive one, as may be judged from the following programme:—

June 10th, *Morning* :—

Registration—Reception by the Director of E.L.M.A., C. W. Sully—A Review of Lighting Progress (R. C. Hawkins) —An Explanation of Lighting Units (W. Imrie-Smith)—Light Measurements (T. Catten).

Afternoon :—

Light and Visibility (W. J. Jones)—Theory and Characteristics of Electric Lamp (A. R. Powell)—Illumination Design (W. Imrie-Smith).

June 11th, *Morning* :—

Characteristics and Development of Lighting Equipment (W. J. Jones)—Business Opportunities in Shop Window Lighting (E. S. Evans)—Office and School Lighting (H. E. Hughes).

Afternoon :—

Modern Lighting in Shop Interiors (E. S. Evans)—Economics of Industrial Lighting (R. C. Hawkins)—Electrical Advertising (H. Lingard).

Evening :—

Visit to Modern Lighting Installation.

June 12th, *Morning* :—

Industrial Lighting Designs (R. C. Hawkins)—The Advantages of Glareless Lamps (C. A. Hughes)—Marketing E.L.M.A. Lamps (W. J. Jones)—Floodlighting (H. Lingard).

Afternoon :—

The Application of Colour in Lighting (L. E. Buckell)—Street Lighting and Traffic Control (H. Lingard)—Special Lighting Problems (H. C. Wheat).

Evening :—

Visit to Modern Lighting Installation.

June 13th, *Morning* :—

Possibilities in Residential Lighting (T. Catten)—Modern Developments in Lighting (R. W. Maitland).

Afternoon :—

Sports Lighting (H. E. Hughes)—Salesmanship, Lighting Service and General Discussion (W. J. Jones).

Evening :—

Dinner, Carr's Restaurant, Strand.

Attention may be drawn to the series of visits to interesting lighting installations in the evenings, which should serve as a useful practical demonstration of principles outlined in the various lectures.

It will be seen, therefore, that the Course promises to be quite as interesting as in previous years, and there should again be a good attendance. Those interested should apply to the E.L.M.A. Lighting Service Bureau (15, Savoy Street, Strand, London, W.C.2), from whom further particulars may be obtained.

North-East Coast Exhibition

THE EXHIBIT OF THE ELECTRIC LAMP MANUFACTURERS' ASSOCIATION.

(Communicated.)

IN view of the fact that the first satisfactory electric lamp was developed by Sir Joseph Swan in the vicinity of Newcastle, it is appropriate that the Electric Lamp Manufacturers' Association should be responsible for the display of a veritable Hall of Light at the North-East Coast Exhibition, recently opened in Newcastle-upon-Tyne. This stand has been designed to indicate how the lamp of the present day, which has evolved so rapidly from Swan's first lamp, may be employed to the greatest possible advantage in every field of lighting service.

The building itself presents a distinctly modern elevation and is constructed on the latest architectural lines with a lavish use of built-in lighting features. The stand is divided into three interiors, consisting of two outer rooms and a central entrance hall, known as the "Hall of Light."

The visitor on entering passes through the luminous doorway which sheds an inviting light over the threshold, and finds himself in the "Hall of Light," where, in great profusion, novel uses of electric light are displayed. The lighting of the ceiling and upper walls is of special interest as indicating the decorative possibilities of the new architectural lighting. This form of lighting, it will be noticed, is not obtained by any system of pendant units installed after the building is erected, but takes the form of lighting fittings actually designed with, and built into, the structure. The fascinating displays set in recesses around the Hall serve to impress still further the amazing possibilities of electric light as an advertising and artistic medium.

The second interior is devoted to the use of electric lamps in the various fields of service. The room is divided into sections, each of which is equipped or furnished in such a manner that realistic settings are provided for the electric lighting. The latest designs in industrial lighting and office lighting are shown in two of the sections, while every conceivable application of the electric lamp as a beautifier of the home is indicated in the other two interiors, which are domestic in character.

All the displays are carefully indicated by tasteful luminous signs, and the visitor will experience no difficulty in being guided round the stand by these silent demonstrators, while Lighting Service Bureau specialists will be in attendance to give advice on all illumination problems.

Passing into the interior devoted to the Lighting Service Work of the Association, the visitor will find particular interest in the model all-electric house, and also the model factory and shop. These models demonstrate in miniature both the corrrect and incorrect use of electric lamps. Another display which is particularly interesting shows the portable demonstration equipment used by the Lighting Service Bureau in connection with lecture demonstrations on various lighting subjects. Four illuminated display panels recessed into the walls indicate the work of the Lighting Service Bureau and are deserving of special attention, since they indicate the widespread nature of this service work and the high ideals upon which it is organized, the aim of the Association being not only to produce electric lamps of the highest quality but to ensure that these lamps are used in the most effective manner.

An Interesting Installation in Finland

Readers will observe on page ix some particulars of an interesting installation in Finland. The illustration depicts the State Archives, which are illuminated by means of "The Wigan" Prismatic Fittings, fitted with 100-watt gasfilled lamps. The lower illustration shows the relative positions of the units, whose depth is comparatively small, allowing the maximum headroom. It will be seen from the letter received with the photographs that, owing to the light-distribution properties of "The Wigan" Prismatic Fittings, it was found that no additional illumination was required between the bookshelves. A feature attending the use of these fittings was the absence of abrupt hard shadow lines and glare, and the even and soft illumination. We understand that this is but one of the many important buildings illuminated by "The Wigan" Prismatic Fittings, and the manufacturers, Messrs. Heyes & Co. Ltd., will be pleased to forward particulars of these fittings to anyone interested.

INDEX (June, 1929).

TRADE NOTES & ANNOUNCEMENTS

THE KANDEM QUARTERLY REVIEW.

The chief feature of the *Kandem Quarterly Review* for April (published by Messrs. Korting & Mathiesen Electrical Ltd.) is an illustrated article on dock-lighting, wherein the great importance of good lighting in this " all-night " industry is pointed out. Another article deals with photographic copying by artificial light and there is a description of new types of table lamps and night lights which specially deserves study. The latter article is of interest as an indication of the modern tendency to revert to local lighting—not in its old and unsatisfactory form, but as a supplement to general lighting where high illumination is particularly needed.

PHILIPS SPECIALITIES.

Messrs. Philips Lamps Ltd. draw our attention to an ingenious new form of adjustable gallery for use with shop-window reflectors, which seems to meet a long-felt want. Whilst the light-centres of electric lamps have been standardized by leading manufacturers, some means of adjustment for lamps of different wattage is very desirable; otherwise the light distribution may be materially changed. The two-part gallery now introduced is simple in form and so designed that no screws need be interfered with when the reflector is removed for cleaning purposes. Another leaflet deals with " Philliray " reflectors, which are available in considerable variety, the polar curve of each type and the lamps for which it is suitable being indicated for each form.

CONTRACTS CLOSED.

The following contracts are announced :—

Siemens Electric Lamps and Supplies Ltd :—

London and North Eastern Rail Company; for 12 months supply of Siemens standard lighting lamps, carbon filament lamps and train-lighting lamps.

London County Council; requirements in electric incandescent lamps for a period of 12 months.

CHURCH LIGHTING IN EALING.

From the General Electric Co. Ltd. we receive a description of the new lighting of St. Peter's, Ealing, illustrated by several effective photographs showing the new and old methods. A feature of the new lighting, by means of G.E.C. flood-lighting units and reflectors equipped with gasfilled lamps, is the complete absence of exposed lamps in the view taken looking towards the altar, for which special lighting is also provided. The vicar and churchwardens, we are informed, enthusiastically approve the new arrangements, and the congregation has shown their satisfaction in a very practical way by subscribing, in less than two days, an amount more than sufficient to defray the balance of the cost of installation.

G.E.C. IPSWICH BRANCH

New Address

We understand that on May 13th the Ipswich branch of the General Electric Co. Ltd. was removed to larger premises in Westgate Chambers, 40B, Westgate Street, Ipswich, where all communications should now be addressed. The telephone number (Ipswich 2379) and telegraphic address (" Electricity," Ipswich) remain the same.